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ASSEMBLY AND APPLICATION OF A SHOCK DATA ANALYSIS SYSTEM.(U)
JUL 81 K KLASSEN, E CLEMENTS
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Shock data analysis systems tend to be either large, digital processing facilities handling batches of hundreds of records, or small, slow, (often analogue) systems which can perform a limited analysis on a small number of records, but which are portable.

This report describes a system in the middle ground — capable of performing complete analysis of a moderate number of records in a reasonable time, accepting analogue magnetic-tape records as input and producing report-ready charts and tables as output.

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20. ABSTRACT (Continued)

The system utilizes standard, off-the-shelf instruments marketed nationwide and easily available, any of which could be replaced by a different supplier's product with little change in operation or performance.

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CONTENTS

Assembly and Application of a Shock Data Analysis System

1. Introduction

Measured data from shipboard shock environments usually consist of analogue magnetic-tape recordings of acceleration and strain versus time. Usually, little analysis is required of strain recordings save spectral analysis and perhaps sums and differences. From the accelerometer recordings, however, it is usually necessary to extract velocities and displacements, and often shock spectra, as well. Shock data analysis facilities tend to run to two extremes of size and capacity. At one end is the large digital processing facility where hundreds of records (from an at-sea ship shock test, for example) are processed in batch, usually after the test is completed. At the under end is the small, often analogue, facility which can do limited analysis of a small number of records, although perhaps very slowly. The latter may be used to advantage for analyzing a few selected critical records in the field, or in the shock simulation lab.

A need exists for a capability in the middle ground - a system capable of doing analysis on a modest number of records in a reasonable time, which accepts analogue magnetic tapes as input and produces report-ready graphs and tables as output, and which is field-transportable if necessary.

This report describes such a system which has been assembled with standard, off-the-shelf instruments which are marketed nationwide and easily available. It is not in any way optimized for the specific task of shock data analysis, hence may not be competitive in speed, cost, etc. to a system which has been optimized in hardware and/or software to this specific application. It furnishes an example of what can be done along these lines with virtually no expenditure of R & D effort, and is an example in that any of its component instruments could be replaced by a different supplier's product with little change in operation or performance.

2. Background

2.1. Shock motions may be described in terms of acceleration -, velocity -, or displacement-time histories, and in all three parameters may vary greatly in waveform complexity. Simpler shock motions may be closely defined by a few waveform parameters, and these may also provide a reliable basis for comparison of shock motions. Shipboard shock, however, is extremely complex. Motions are typified by waveforms of high frequency range, high dynamic range and long duration which cannot be defined adequately by a few parameters. The additional descriptions found most useful for a motion of this type are the shock spectrum, which may be interpreted as a measure of the effects of a shock motion, and the design shock spectrum, which provides the data needed to design a structure to withstand it. Each provides a basis for comparing shock severities, and applies equally well to shock motions of all degrees of complexity of waveform. The general nature of shock motions, shock spectra and design shock spectra are discussed in Refs. (1) and (2).

2.2. While a shock motion may be identified equally well by its acceler-

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ation, velocity or displacement waveform, one of them will usually be most convenient for a given application. However, in most situations only acceleration can be measured properly. This is almost always the situation in the case of shipboard shock, and the bulk of data in this field will consist of records of acceleration and strain versus time, with perhaps a small fraction being records of velocity versus time. Thus, an analysis system for shipboard shock motion records must be able to produce time histories of acceleration, velocity and displacement, as well as shock spectra and design shock spectra, given input signals representing acceleration - or velocity-time histories, and preferably from displacement-time histories as well. Since shipboard shock motions are among the most demanding in terms of functional requirements, an analysis system capable of handling them will also be able to handle shock motions of most other types.

3. Analysis System Characteristics

3.1. The principal application of the system is the analysis of shock motions measured on laboratory shock machines. This includes those which generate simple-pulse shock, but most prominent are those which generate shipboard shock type environments: the Lightweight Shock Machine (LWSM), the Mediumweight Shock Machine (MWSM), the Floating Shock Platform (FSP) and the Large Floating Shock Platform (LFSP) (Ref. 3). Tests on these machines will be lightly instrumented compared to at-sea tests of ships and submarines, or some of the more specialized test vehicles. The typical instrumentation suite may be a few channels on the simpler-pulse machines and the LWSM, up to a dozen on the MWSM and FSP and a few dozen on the LFSP, while on some occasions several times as many channels may be required. Normally, about one-third of the total channels will fall in the category of equipment input motions, while most of the remainder will be equipment response motions and structural strains.

3.2. The function of the analysis system is to accept analogue input signals, perform whatever processing is required, and produce output representations of the desired quantities, scaled in the appropriate engineering units, in graphical or tabular form, and in video or hard-copy display. All signals require A-D conversion and storage, scaling and display. All motion signals require in addition computation and display of acceleration, velocity and displacement, each properly scaled, which requires the functions of integration and possibly differentiation. Input motion signals, and some response motion signals, also require the computation of maximax and residual shock spectra. This last computation is by far the most complex and time-consuming, but is needed for only a few channels. For a suite of a dozen channels of assorted information, the system will perform a complete analysis in an hour or two.*

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* Shock spectrum analyzers are available commercially, and are typically compact units and very fast. As stand-alone systems, they are lacking in that they cannot do a complete analysis (integration and scaling, etc.) and have no display. As components for calculating shock spectra they are wanting in that they cannot compute undamped spectra and their analysis frequencies are fixed.

3.3. Since the analysis system is an assembly of component units designed for use as independent, general purpose instruments, it has a great degree of flexibility. With different switch settings, it would function equally well for analyzing earthquake motions or blast loadings. A brief description of each functional block of the system and its capabilities follows.

3.3.1. Magnetic-Tape Recorder

The primitive form of shock data records is usually FM magnetic tape. The recorder used with the analysis system has 14-track record/reproduce capability, plus edge tracks for voice annotation. The normal configuration has two housekeeping channels, one of them DR for a tape-speed servo reference signal and the other an FM channel devoted to time-code in IRIG B format, and 12 FM data channels. All FM channels are IRIG Intermediate Band I. Normal recording speed is 30 ips, giving a nominal bandwidth of 0 - 10 KHz. The recorder can be operated at tapes speeds from 15/16 to 120 ips, allowing the traditional analysis tricks of data speed-up and slow-down; record density can be changed by rearranging plug-in components on the electronics cards. Output level is normally set for 1v rms for ±40% peak-to-peak (sinusoidal) modulation. This particular unit was selected because it performs a set of canned calibration and set-up routines under control of a built-in microprocessor, and because it is a portable unit. Both features are convenient for field operations.

3.3.2. Auxiliary Equipment

The principal auxiliary equipment units are a time-code generator/reader, a direct-writing oscillograph, and a storage CRO. In generator mode, the time-code unit produces an IRIG B code for recording in the magnetic tape. In reader mode, it monitors the recorded time-code and produces a pulse when a chosen time value occurs. This time can be selected to the millisecond and provides a start signal to the transient-storage unit (discussed below) and facilitates synchronization of the recorded data signals. The other units, the CRO and oscillograph, provide quick-look display of the recorded data signals and time-code. The CRO is a two-channel, single time-base type similar to many currently available. The oscillograph produces strip charts of up to 12 channels with a bandwidth of 0 - 5 KHz at paper speeds from 0.1 to 160 ips.

3.3.3. Data Filter

The data signals output from the tape recorder are passed through an 8-channel data filter. Each channel has a low-pass characteristic with cutoff frequency selectable from 1 Hz to 15 KHz, and is direct-coupled. The unique features of this unit are that the filter characteristic is optimized for linear phase-shift within pass-band, minimizing envelope distortion, and that phase-shift between channels is closely controlled at no more than 2° between any pair. The filter characteristic also features a cutoff rate of 43 db/octave, so that aliasing is negligible for sampling frequencies of 4.2 times the cutoff frequency or higher. Each channel has unity

gain, and can accept inputs of up to 10 V. As used in the analysis system, the cutoff frequency is normally set to 1KHz.

3.3.4. Transient Storage Unit

The transient-storage unit contains seven independent AD and digital storage channels with a common time-base. Each channel can be operated in an inhibit mode which preserves the existing stored signal. The unit can be operated in a self-triggered mode, where the signal in any channel can be used to initiate the capture of the signals in all channels which are not inhibited. As used in the analysis system, the capture-initiate signal is derived from the time-code reader to preserve commonality of time-base between successive batches of signals. Upon initiation, each channel captures 4096 10-bit samples of its signal, for a dynamic range of 60 db. As used in the analysis system, the channel full-scale range is ± 2 V; it can be varied from ±0.1 to ±5V. The sampling period used is 100 microsec., for a total record length of 400 millisec.; the sampling period can be varied from 5 microsec. to 2.5 sec. Each channel provides outputs of the digitized "staircase" and smoothed analogue versions of the stored signal waveform. As used in the analysis system, the signal stored in any selected channel is read out on the IEEE-488 bus in bit-parallel, character-serial ASCII code. This particular unit was selected because of its 7-channel capacity and the fact that each A-D converter and storage channel is functionally independent from the others.

3.3.5. Processor and Display Unit

The processor and display unit is a large-screen desk-top computer and peripherals. The computer has 64K-byte memory and a resident BASIC interpreter, leaving some 53K-bytes of usable memory. Additional ROM packs provide signal processing routines, including integration and differentiation, and text-editing capability. The principal display is a built-in large screen CRT. The peripherals include a hard-copy unit which gives a permanent record of the CRT display with reduced size, and a digital X-Y plotter which gives high quality graphs up to 11 x 17 in. Other peripherals are a high capacity disc-file manager, which allows a large library of programs to be resident on floppy disc, and an additional tape-cassette drive-unit, allowing more flexibility in data transfer. All of these components are produced by the same manufacturer, and are configured and interfaced to form a compatible system. This (processor and display) unit was selected because it possesses the requisite computational power and has an excellent repertoire of graphics routines. Other features are good man-machine interface, BASIC interpreter and large-screen display. These seem to assist the intended user profile, engineering/technical personnel without extensive familarity with computing systems, in learning to operate this analysis system with a minimum of instruction. The existence of a comprehensive assortment of proven peripherals was also a factor of consideration. Another feature of the computer is that it can also be operated as a high-speed (9600 baud) intelligent

terminal, should operation with a larger host computer be desirable. The last peripheral in the system is a high-speed printing terminal from another manufacturer. When used with the analysis system, it functions as a moderately fast line-printer.

3.4. The functional block diagram of the analysis system is in shown in Fig. 1.

4. Computation of Shock Spectra

4.1. Recalling that the shock spectrum of a shock motion may be interpreted as the maximum relative displacements of a set of massless single-degree-of-freedom systems whose bases are forced to follow the motion, it is apparent that shock spectra may be derived for any degree of damping. For the purpose of comparing shock motion environments and specifying design shock spectra, the undamped version is preferred, since the damped spectra are less sensitive to variations in the input motion. Shock spectra can be computed from the differential equation of motion, or from the corresponding integral equation. Either form can be expressed to involve the input motion in terms of acceleration, displacement or velocity. The procedure used here is that of numerical solution of the differential equation relating relative displacement to input accleration. The computational procedure requires the input to the program as the acceleration-time history of the shock motion. The computational procedure uses the algorithm described in Ref. (4).

The equation of motion for an undamped oscillator of frequency ω is

$$(1) \qquad \ddot{X} + \omega^2 X = -\ddot{Z}$$

with the solution for the relative displacement X

$$(2) \qquad X(t) = X_o \cos \omega t + \frac{\dot{X}_o}{\omega} \sin \omega t - \frac{1}{\omega} \int_o^t \ddot{Z}(\tau) \sin \omega(t-\tau)\, d\tau .$$

The numerical integration equation derived by G. O'Hara (Ref. 4) is

(3)
$$X_{n+1}\omega = X_n\omega \cos \omega h + \dot{X}_n \sin \omega h - \frac{S_n(1-\cos \omega h)}{\omega h} - S^2_{n-1}\left(\frac{1+\cos \omega h}{2\omega h} - \frac{\sin \omega h}{\omega^2 h^2}\right)$$

with a parabolic approximation for the digitized input function $\dot{Z}(t)$; here $S_n = \dot{Z}_{n+1} - \dot{Z}_n$

and $S^2{}_{n-1} = S_n - S_{n-1} = \dot{Z}_{n+1} - 2\dot{Z}_n + \dot{Z}_{n-1}$

(note that $S^2{}_{n-1}$ is the second difference, not a square)

so that

$$(4) \qquad \dot{Z}(t) = \dot{Z}_n + \frac{S_n}{h} t + \frac{S^2_{n-1}}{2}\left(\frac{t^2}{h^2} - \frac{t}{h}\right).$$

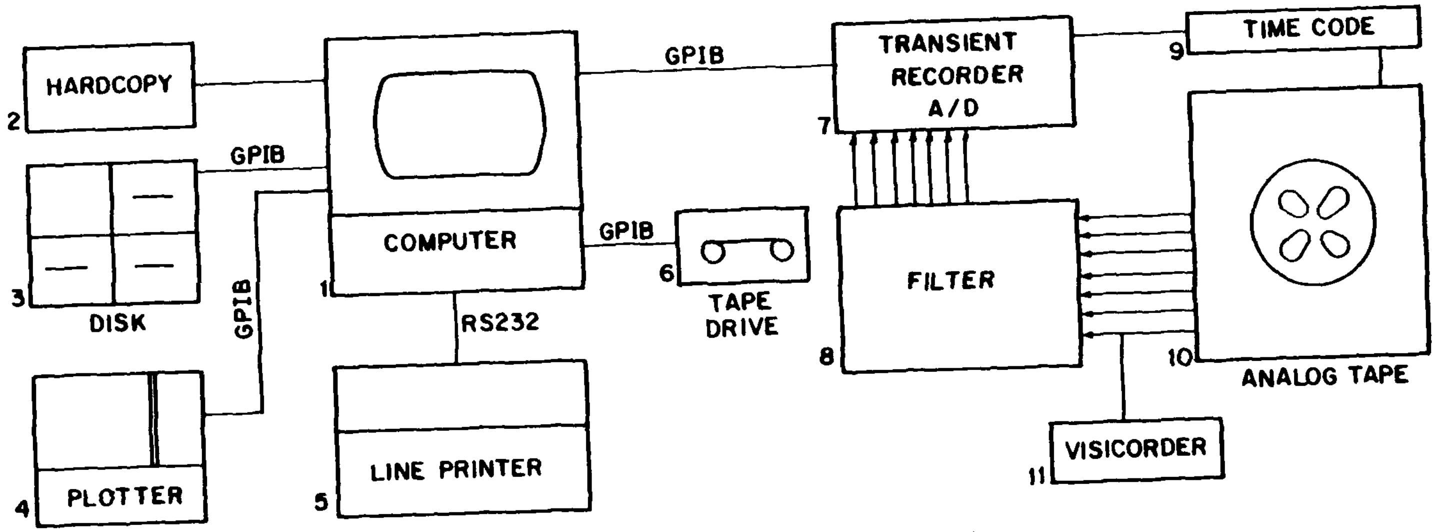


Fig. 1 — Functional block diagram of the analysis system.

In these equations, h is the time interval of integration.

By eliminating $\dot{X}_n$ in (3), R. Bort's implementation of equation 3 (Ref. 5) is

$$(5) \quad X(t + h) = 2\, X(t) \cos \omega h - X(t-h) + h\, [\dot{Z}\, (t + h/2) - \dot{Z}(t - h/2)]$$

Equation (5) has been applied in this program because it consists of only three additions. As implemented here, the term in brackets $[\dot{Z}\,(t + h/2) - \dot{Z}\,(t - h/2)]$ is identified as $h\ddot{Z}\,(t)$, a sample point from the digitized input acceleration record. Before processing input data the $2 \cos \omega h$ term is determined and stored in array C. All scaling factors are deferred to the end of the calculation for each analysis frequency.

In order to cut down calculation time, the fact that lower analysis frequencies require fewer periods to reach peak response than higher frequencies is employed. The number of periods per analysis frequency considered in the processing routine is given by

$$(6) \qquad Q = \frac{F}{5 \log F}$$

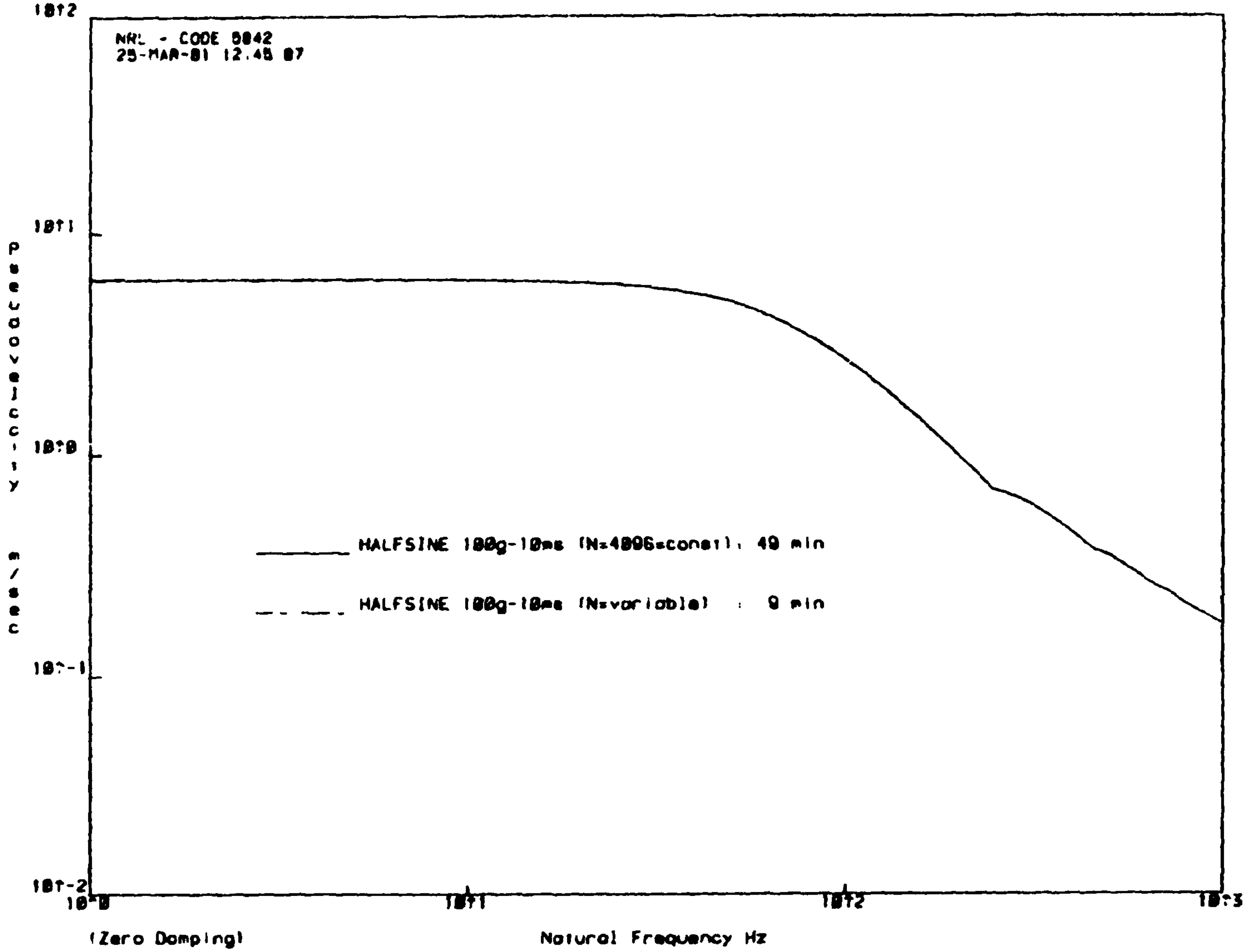
where $F = \omega/2\pi$.

The second procedure to speed up the program selects data points with respect to cutoff frequency and analysis frequency. The calculation time has been reduced this way from about 50 min. to 8 min. while producing only a minor error (see Fig. 2A,B).

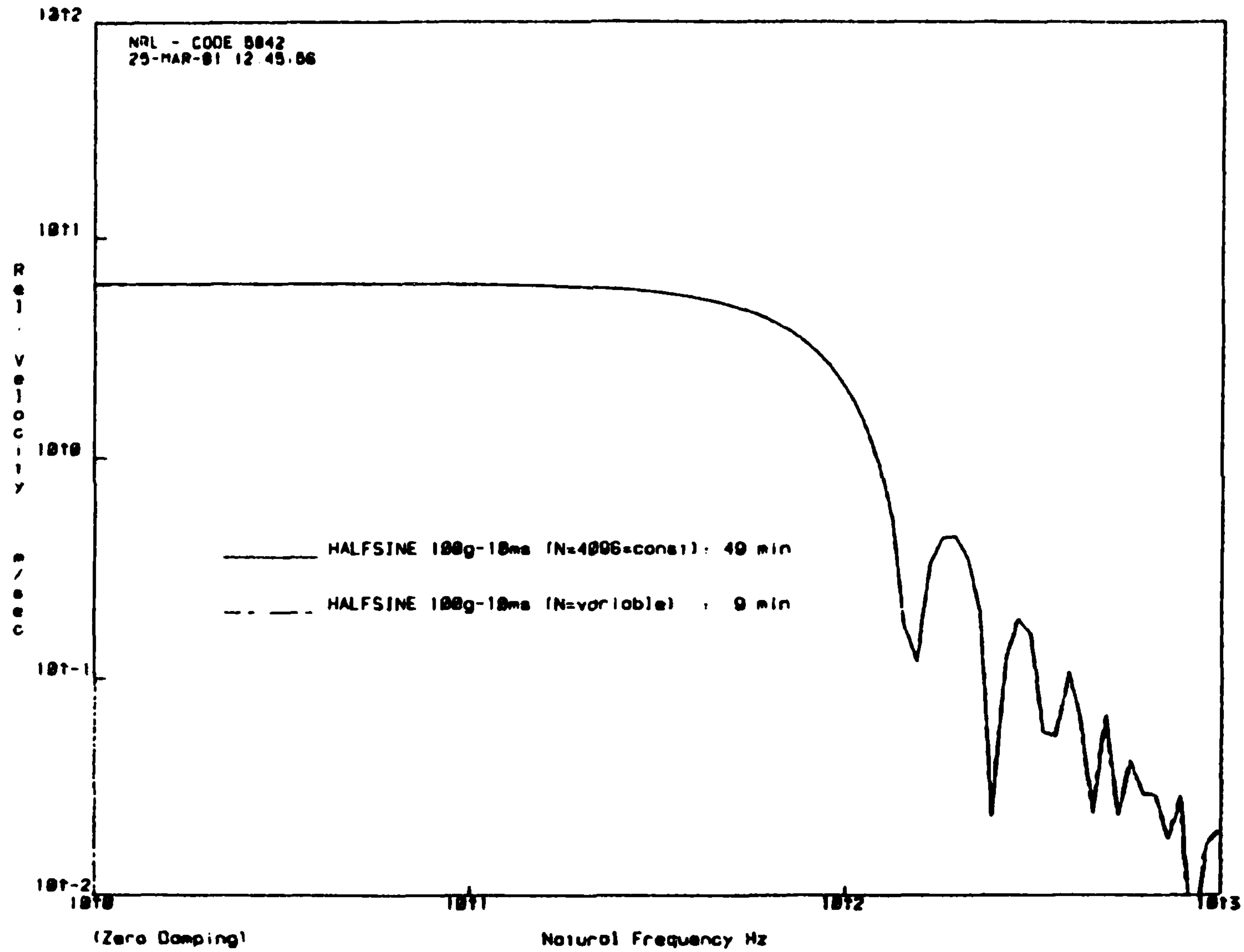
5. System Operator's Manual

5.1.1. It is assumed that a time record of the shock motion - including a calibration step - is available on an analog tape and a time code is recorded on a separate track of the tape. Playing back the record (or calibration step) and the time code on the Visicorder, determine the millisecond preceding the starting time of the record. Set the time code generator to open the time gate and trigger the transient recorder. The transient recorder accomplishes the A/D - conversion and stores the digitized time record in its memory. An interface bus allows the computer to have access to the seven channels (memories) of the transient recorder. Further data processing is done under the control of the program listed in the Appendix.

5.1.2. This program is written in BASIC and runs on the desktop computer Tektronix 4054. The three parts of the program are stored on the disc in three files (a back up tape cartridge contains the program in binary code). Part I reads the calibration step and the time record from the memory of the transient recorder, and calculates shock spectra. Part II contains all output procedures. Part III is basically the same as Part I except that it reads a calibrated digital time record from the external tape unit rather than from the transient recorder. Both Part I and Part III use the output



(a) Maximax shock spectrum



(b) Residual shock spectrum

Fig. 2 — Error introduced by data decimation. Maximax (a) and residual (b) shock spectrum computed from the complete (4096) and decimated data sets for a half-sine acceleration pulse.

procedures in Part II.

5.2 Starting Up

The computer and at least half of the units connected with the computer by interface bus must be turned on. To run the program, set the clock on the disc drive, mount the unit, load the program and enter "RUN".

Example:
Enter: CALL "SETTIM", "20 - MAR -81 □* 8:30"
Press: RETURN
Enter: CALL "MOUNT",Ø , A$
Press: RETURN
Enter: OLD " @ SPRGM/PART I"
Press: RETURN
Enter: RUN
Press: RETURN

Message on the Screen:
SPRGM/PART I is loaded (default conditions)!

The corresponding procedure for using binary tape is either:
Enter: FIND 2
Press: RETURN
Enter: CALL "BOLD"
Press: RETURN
Enter: RUN
Press: RETURN

or simply press: AUTOLOAD

While running the program, the computer indicates a need of communication with the user by a "beep" tone and a message on the screen.

* The symbol □ indicates one space.

5.3 Default Conditions

Default conditions are listed in line 290 to 500 in the Appendix. All default parameters may be changed at any time by entering the desired values from the keyboard (e.g. entering F2 = 500 changes the upper analysis frequency to 500 Hz). The current value of every parameter can be checked by entering the parameter and pressing RETURN: the current value of the parameter appears on the screen.

The most important parameters defined by default conditions are explained below:

- F1, F2: Lower/upper analysis frequency: can be any positive value between 1 and 1000.
- CØ: Number of analysis frequencies between F1 and F2: depends on memory available (Part I up to about 110, Part III about 160). CØ = 1 is possible also.
- F8: Cut off frequency of low pass filter (default 1000 Hz).
- N1, N2: Lower/upper value of y-axis in log display

N6, N7: Lower/upper value of x-axis in log display

D: Primary address for output devices:
32 screen
3 ext. tape
4 plotter
40 printer

P: selects grid in log display:
0<P<10 sets grid line at P
P>10 no grid
(P must not be zero!)

O: indicates the part of the program currently loaded in the memory
1. Part I
2. Part II
3. Part III
(Do not change parameter O from the keyboard).

M9: Calibration matrix.

A2: Offset-correction matrix.

5.4. User Defined Keys

The first row of user defined keys (No. 11 through 15) are used with program Part I or III. All other user defined keys (No. 1 through 10 and 16 through 20) belong to program Part II. User Defined Key No. 4 and 5 allow switching from program Part I or III to Part II or vice versa. Pressing a user defined key which belongs to a program part not currently loaded in the memory causes an error message to appear on the screen.

The following describes each user defined key and the system's reaction.

5.4.1. First Row (No. 11 through 15)

User Defined Key No 11 triggers the calibration routine in program Part I. After the time-record has been defined as a displacement, velocity or acceleration record there are two ways to fill the calibration matrix M9 with the calibration factors for each channel. First the calibration factor may be entered from the keyboard in input units per 1 Volt, or secondly, the calibration step may be read from each channel of the transient recorder. In the latter case the calibration level has to be entered in appropriate units before the computer reads the content of each channel and displays it on the screen. The user may define the calibration level by means of setting the crosshair first to the upper and then to the lower calibration level. The calibration factor (i.e. input unit/digit) for this particular channel will be assigned to an element of calibration matrix M9. The program starts this procedure all over again until the calibration steps of all 7 channels have been read. If the program encounters a channel set to ground or calibration mode an appropriate message appears on the screen and no calibration factor will be defined for this particular channel. The program proceeds with the next channel.

User Defined Key No. 12 reads the time record from a defined channel of the transient recorder and displays a plot of acceleration,

velocity and displacement vs time on the screen. Also each maximum and minimum value is printed.* When running program Part I, the calibration routine (key 11) must be completed before using Key No. 12. With program part III, User Defined Key No. 12 causes the computer to read the time record (including other important information like calibration factor, time step, etc.) from the external tape.

The read routine has to be completed for each record before calculating shock data by pushing User Defined Key No. 13. The computer then calculates shock data of the time record that has been input by means of Key 12.

Using the mathematical algorithm described above, the program computes:

1. Analysis Frequency
2. Pseudo velocity → Maximax-Shock Spectrum
3. Rel. Velocity → Residual-Shock Spectrum (or Fourier Transform)
4. Rel. Displacements
5. Abs. Acceleration
6. Time when maximum occurs
7. Phase

While calculating, the computer displays on the screen the serial number of analysis frequency (from 1 at the lowest to CØ at the highest), the analysis frequency, the pseudo-velocity, and the number of data points used for the calculation of shock spectra for each analysis frequency. The computing time is also given at the end of the procedure.

The number of analysis frequencies (1 to 160*), as well as any interesting range of analysis frequencies between 1 and 1000 Hz, can be chosen. (Note that F_2 has to be larger than F_1).

The time record and all important information, such as calibration factor, time step, etc. can be stored on a defined file of the external tape by pushing User Defined Key No. 14. Additional analysis can be done on this time record by means of part III of the program (refer to User Defined Key No. 12). An offset correction of the time record can be made with the procedure of User Defined Key No. 15. The first integral of the time record is displayed on the screen and the user may define the zero line by means of the cross hair. After pushing any key the computer calculates an offset correction for this particular channel and considers that at all later operations. This procedure may be repeated several times.

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* The title or description of the time record is stored in string W$ and appears on the top of the display. It may be changed anytime by redefining W$

*Depends on memory available for the calculation (program part III allows up to 160 analysis frequencies).

However, the user has to realize that this procedure requires some actual value to be known.

5.4.2. Second Row (No. 1 through 5)

The results of the shock spectra computation (Key No. 13) can be saved by pushing User Defined Key No. 1. This causes the computer to write all data on a defined file of the external tape. These shock data can be read back with User Defined Key No. 2.

A numerical output of all analysis data can be retrieved by pushing User Defined Key No. 3. As for all other output procedures the primary address of the selected output device (screen, printer, or plotter) has to be specified here.

User Defined Key No. 4 makes the computer load part II of the program while keeping all values of all parameters and variables in its memory.

5.4.3. Third Row (No. 16 through 20)

The third row of user defined keys produces a linear plot of the shock spectra. The amplitude scale is automatically adjusted to the output.* Any range of analysis frequencies can be selected.

User Defined Key No. 16 displays a plot of pseudo-velocity vs. analysis frequency (maximax)
User Defined Key No. 17 displays a plot of rel. velocity vs. analysis frequency (Residual)
User Defined Key No. 18 displays a plot of acceleration vs. analysis frequency.
User Defined Key No. 19 displays a plot of rel. displacements vs. analysis frequency.
User Defined Key No. 20 displays a plot of phase (0 to 180 degree) vs. analysis frequency.

5.4.4. Fourth Row (No. 6 through 10)

A logarithmic plot of analysis data can be retrieved by pushing any of the user defined keys in the fourth row. User Defined Key No. 6 displays the Maximax Shock Spectrum, No. 7 the Residual Shock Spectrum, and No. 8 both of them. User Defined Key No. 9 allows some analysis work on the screen in determining modal frequencies and appropriate shock spectrum values (the Design Shock Spectrum) by placing the two crosshairs at points of interest. The thumbwheels on the keyboard control the movement of the crosshairs When a keyboard key is pressed, the location of the crosshair is marked and the appropriate analysis frequency and shock spectrum value is printed beside the graph-plot. When the key "Ø" is

*except phase is always displayed between 0 and 180 degrees.

pressed, the crosshair disappears from the screen. (Note: this procedure works with the screen only!)

User Defined Key No. 10 gives a plot of a number of different shock spectra stored on the external tape. Each spectrum is drawn with a different dark line and the description of the spectrum is printed wherever the crosshairs have been placed.

6. Examples of Analysis System Output.

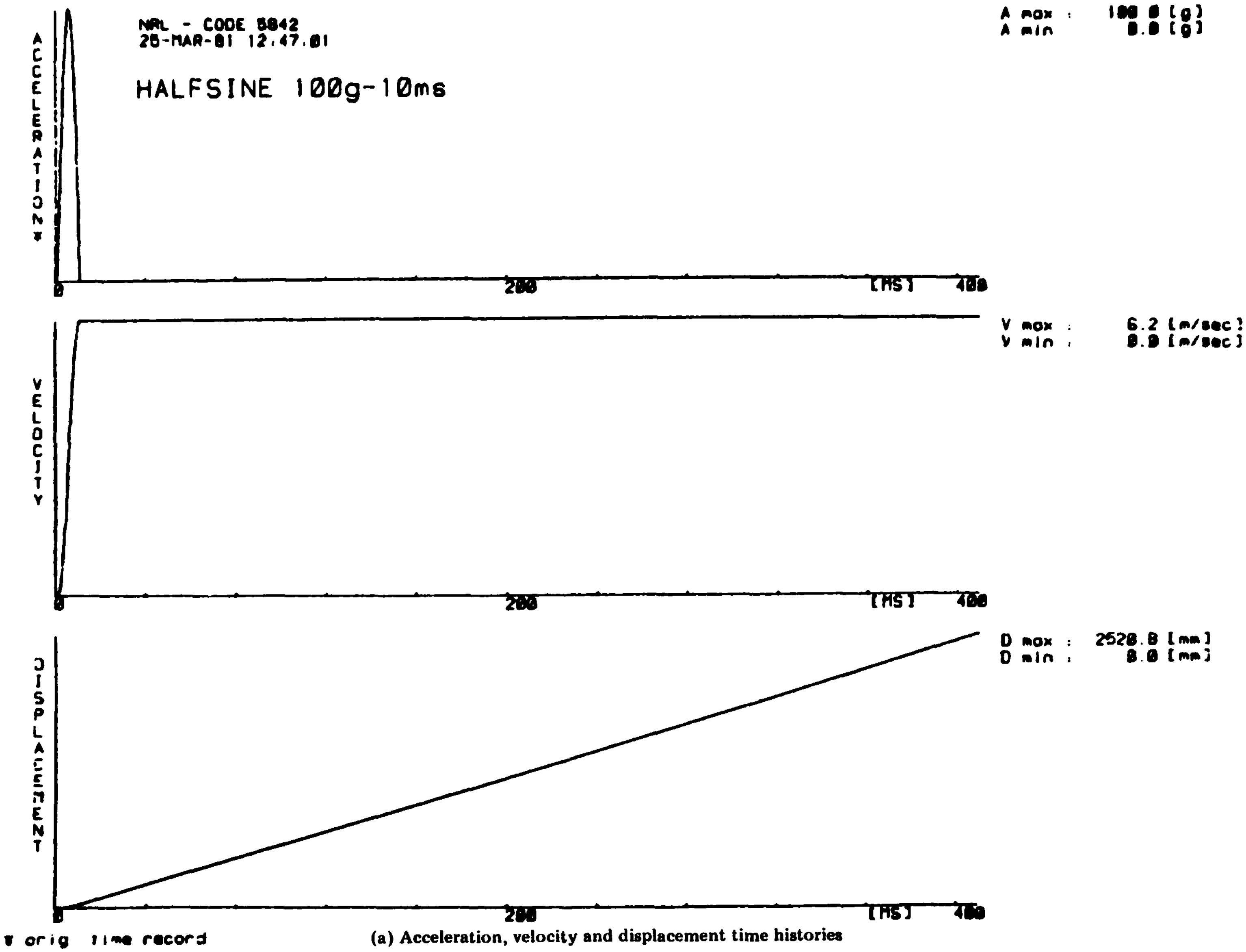
6.1. Figures 3 and 4 show the various output formats which can be selected. These were made using the hard copy unit, which produces a reduced-size version of the CRT display. Higher quality graphs can be obtained from the plotter.

6.2. For Fig. 3, the input record was a half-sine acceleration pulse. The original, integral and double integral are shown in Fig. 3A as scaled acceleration, velocity and displacement. The maximax shock spectrum is shown in linear plot, without grid-lines, in Fig. 3B, and in log-log plot, with grid-lines, in Fig. 3C. The maximax and residual are shown in log-log plot, with factor-of-ten grid-lines, in Fig. 3D. Finally, a tabular listing of all computed data is shown in Fig. 3E.

6.3. The input record for Fig. 4 was an acceleration-time history recorded on a resilient structure aboard the Floating Shock Platform with shot standoff of 20 ft. The acceleration, velocity and displacement waveforms are shown in Fig. 4A, utilizing the offset correction routine described above: i.e., requiring the average velocity near the 400 millisec. mark to be zero. The maximax and residual spectra are given in Fig. 4B, and again in Fig. 4C, which demonstrates the extraction of design shock spectral parameters. Modal frequencies and shock spectrum values are lined up with the CRT crosshairs, and their values tabulated. The values read are also identified on the graph. The tabular listing of computed data is shown in Fig. 4D.

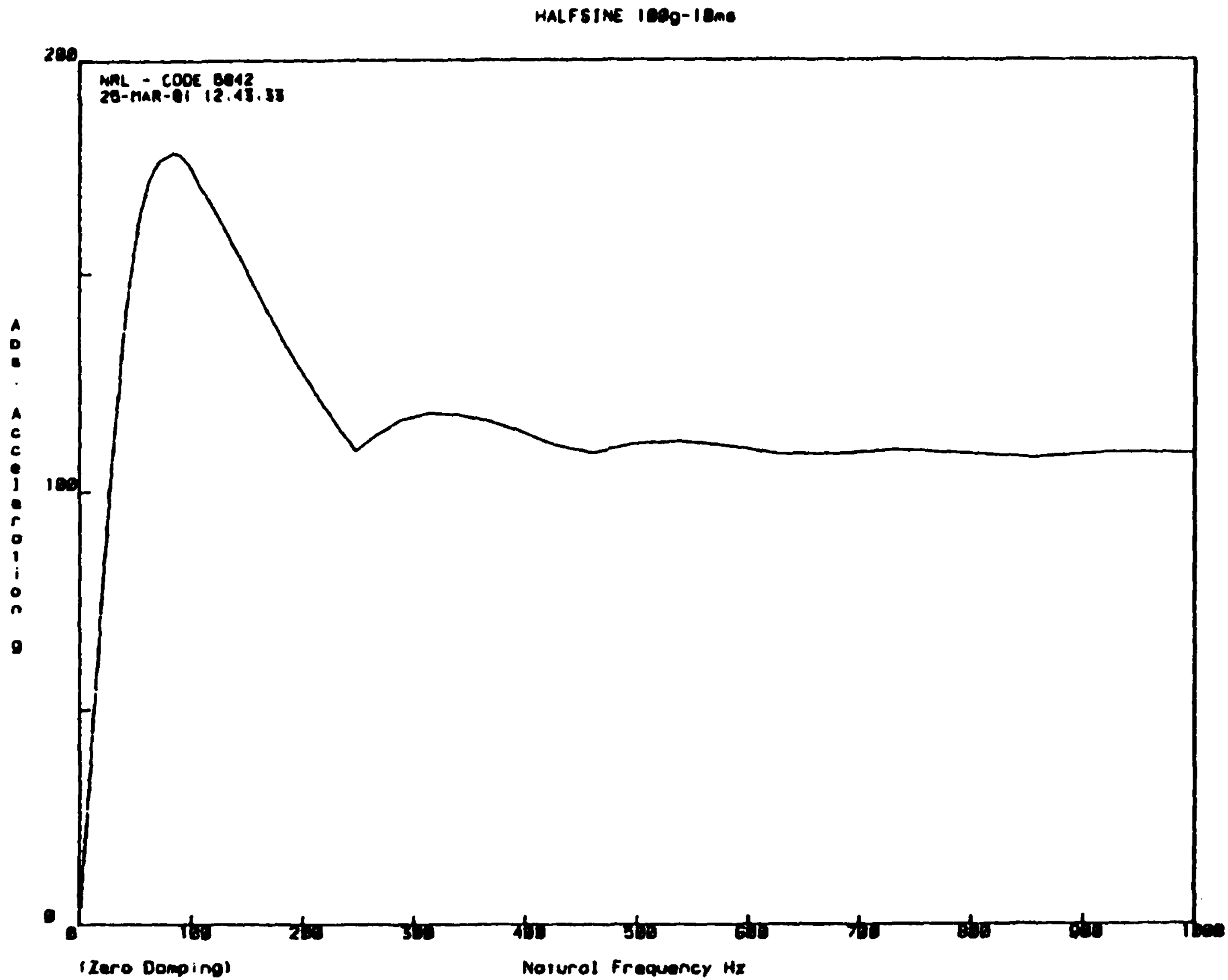
7. Acknowledgements

As is indicated in the text, the computational algorithm was developed by G. J. O'Hara in 1962, and used extensively at NRL and elsewhere since then. The implementation of this algorithm used here was devised by R. L. Bort. The authors' thanks to both gentlemen.



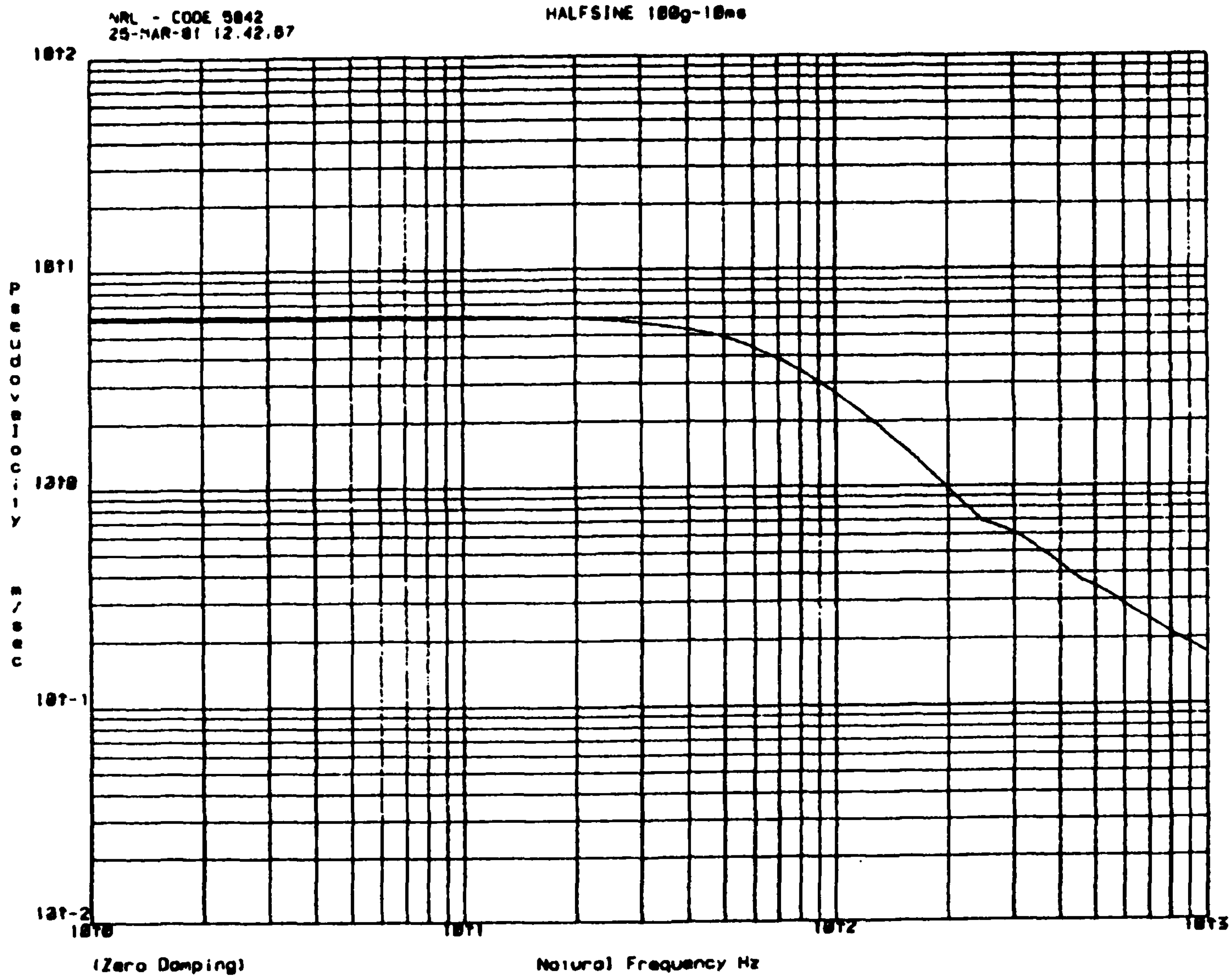
(a) Acceleration, velocity and displacement time histories

Fig. 3 — Output for analysis of a half-sine acceleration pulse



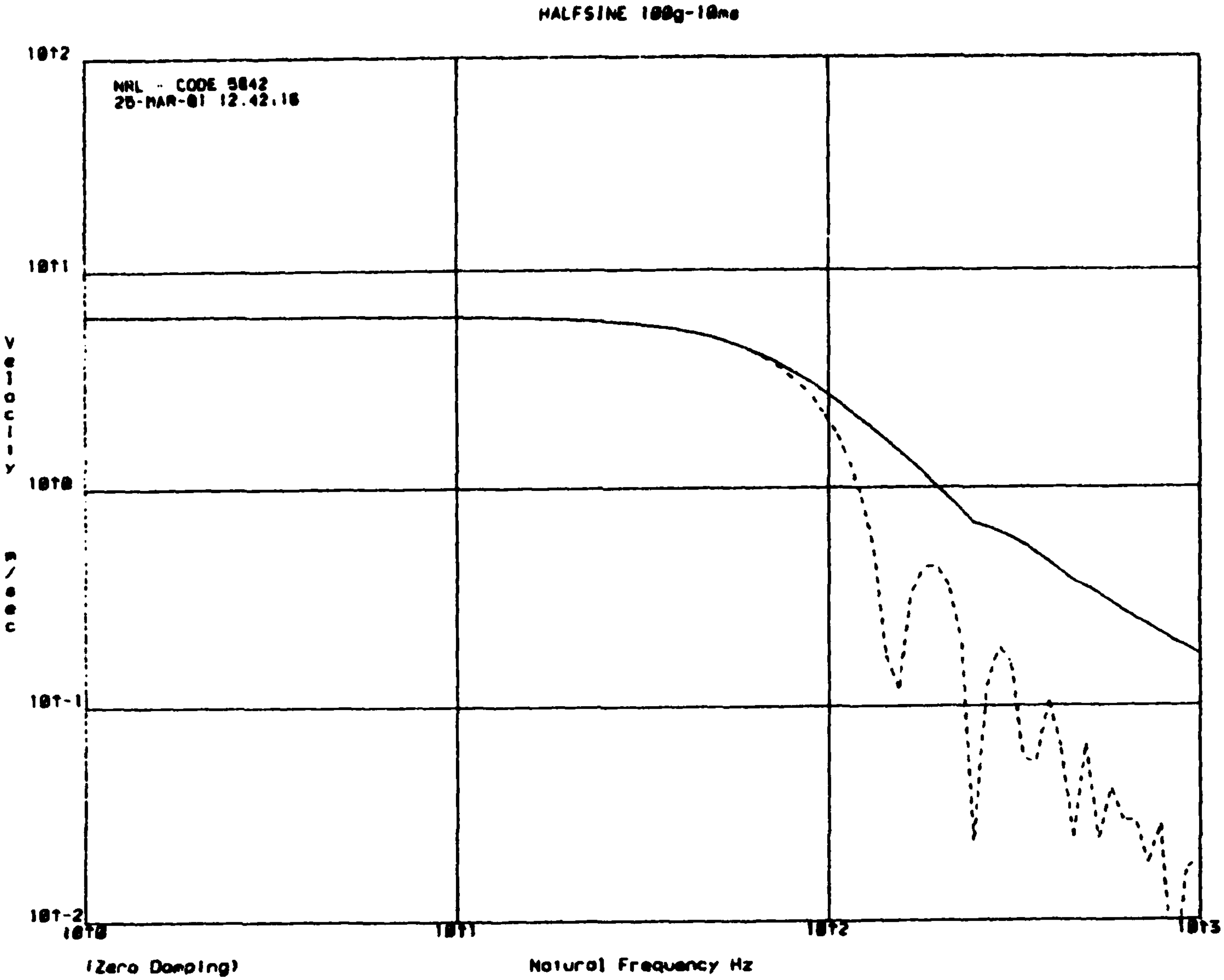
(b) Maximax shock spectrum, linear plot, without grid

Fig. 3 — Output for analysis of a half-sine acceleration pulse



(c) Maximax shock spectrum, log plot, with grid

Fig. 3 — Output for analysis of a half-sine acceleration pulse



(d) Maximax and residual shock spectra, log-plot, with factor-of-ten grid

Fig. 3 — Output for analysis of a half-sine acceleration pulse

HALFSINE 100g-10ms

FREQ (HZ)	SHOCK SPECTRUM (MM)	SHOCK SPECTRUM (M/S)	SHOCK SPECTRUM (G)	(MS)	FOURIER TRANS (M/S)	FOURIER TRANS (DEG)
1.0	993.22	6.24	4.0	255.25	6.24	-178
1.1	903.03	6.24	4.3	236.25	6.24	-178
1.2	850.38	6.24	4.7	219.25	6.24	-178
1.3	786.86	6.24	5.1	203.25	6.24	-178
1.4	728.08	6.24	5.5	189.25	6.24	-178
1.5	673.69	6.24	5.9	174.75	6.24	-177
1.6	623.36	6.24	6.4	162.25	6.24	-177
1.7	576.78	6.24	6.9	150.25	6.24	-177
1.9	-533.68	-6.24	-7.4	408.25	-6.24	-177
2.0	-493.80	-6.24	-8.0	378.25	-6.24	-176
2.2	-456.90	-6.24	-8.7	350.25	-6.24	-176
2.3	422.74	6.24	9.4	111.75	-6.24	-175
2.5	-391.14	-6.24	-10.2	300.75	-6.24	-175
2.7	361.90	6.24	11.0	96.25	-6.24	-175
3.0	-334.83	-6.24	-11.9	258.25	-6.24	-174
3.2	-309.78	-6.24	-12.8	239.25	-6.24	-174
3.5	286.60	6.23	13.8	366.25	6.23	-174
3.7	265.15	6.23	15.0	339.25	6.23	-173
4.0	245.30	6.23	16.2	314.25	6.23	-173
4.4	-226.92	-6.23	-17.5	176.75	6.23	-172
4.7	209.91	6.23	18.9	269.75	6.23	-171
5.1	194.17	6.23	20.4	54.25	6.23	-170
5.5	179.60	6.22	22.0	231.75	6.22	-170
6.0	166.11	6.22	23.8	214.75	6.22	-169
6.4	153.62	6.22	25.7	199.25	6.22	-168
7.0	142.05	6.21	27.7	184.75	6.21	-167
7.5	131.35	6.21	30.0	171.25	6.21	-166
8.1	121.43	6.20	32.3	158.75	6.20	-165
8.8	-112.25	-6.20	-34.9	204.25	-6.20	-164
9.5	103.74	6.19	37.7	136.75	-6.19	-163
10.3	-95.86	-6.18	-40.7	70.25	-6.18	-161
11.1	-88.56	-6.17	-43.9	72.75	-6.17	-160
12.0	-81.79	-6.16	-47.3	67.75	-6.16	-157
13.0	-75.51	-6.15	-51.1	140.25	6.15	-156
14.0	-69.69	-6.13	-55.0	58.75	6.13	-155
15.1	-64.29	-6.11	-59.3	54.75	6.11	-153
16.3	59.28	6.09	63.9	142.75	6.09	-150
17.7	54.63	6.06	68.7	19.25	6.06	-149
19.1	50.30	6.03	73.9	18.25	-6.03	-144
20.6	46.28	6.00	79.4	17.25	-6.00	-143
22.3	-42.54	-5.96	-85.3	38.75	-5.96	-140
24.1	-39.06	-5.91	-91.4	119.25	5.91	-133
26.0	35.92	5.86	97.9	14.75	5.86	-133
28.1	-32.79	-5.80	-104.7	31.75	5.80	-126
30.4	29.96	5.73	111.7	46.25	-5.72	-126
32.9	27.32	5.64	119.0	12.75	-5.64	-119
35.5	-24.85	-5.55	-126.4	26.25	5.55	-114
38.4	22.54	5.44	133.9	63.75	5.44	-110
41.5	-20.36	-5.31	-141.3	23.25	-5.31	-101
44.8	18.32	5.16	148.5	10.75	-5.16	-94
48.5	-16.41	-5.09	-155.3	41.25	4.99	-94
52.4	-14.60	-4.81	-161.4	78.75	-4.80	-87
56.6	-12.91	-4.59	-166.6	106.75	-4.59	-75
61.2	11.34	4.36	171.0	9.25	4.34	-68
66.1	9.91	4.12	174.5	8.75	-4.07	-58
71.4	8.59	3.86	176.6	8.25	3.77	-45
77.2	7.39	3.58	177.5	8.25	3.42	-31
83.4	6.36	3.33	178.4	7.75	-3.05	-19
90.2	5.43	3.09	177.8	7.25	2.67	-9
97.4	4.59	2.81	175.7	6.75	-2.24	-6
105.3	3.84	2.54	171.5	6.75	-1.80	23
113.8	3.22	2.30	168.0	6.45	1.36	41
123.0	2.69	2.08	163.7	6.15	-0.93	57
132.9	2.23	1.86	158.8	5.85	-0.53	76
143.6	1.85	1.67	153.4	5.55	0.17	98
155.2	1.52	1.48	147.7	5.25	-0.12	-64
167.8	1.25	1.32	141.6	4.95	0.32	-40
181.3	1.02	1.16	135.3	4.65	0.43	-14
195.9	0.83	1.03	128.8	4.45	0.44	19
211.8	0.68	0.90	122.4	4.15	0.35	48
228.8	0.55	0.79	115.9	3.95	0.20	84
247.3	0.44	0.69	109.5	3.75	-0.02	122
267.3	0.39	0.66	113.3	6.65	0.12	-31
288.9	0.35	0.63	116.6	6.25	-0.19	17
312.2	0.30	0.59	118.0	5.95	0.16	63
337.4	0.26	0.54	117.9	5.55	-0.06	114
364.6	0.22	0.50	116.4	5.15	-0.05	-18
394.0	0.18	0.45	114.0	4.85	0.10	35
425.8	0.15	0.41	110.7	4.55	0.06	105
460.2	0.13	0.37	109.9	6.25	-0.02	-13
497.3	0.11	0.35	111.1	5.85	-0.07	64
537.4	0.10	0.32	111.5	5.45	0.02	145
580.8	0.08	0.30	110.5	5.15	0.04	35
627.7	0.07	0.27	108.6	4.75	-0.03	125
678.4	0.06	0.25	108.6	5.85	-0.03	48
733.1	0.05	0.23	109.5	5.45	-0.02	160
792.3	0.04	0.21	108.8	5.05	-0.03	79
856.2	0.04	0.20	107.7	5.85	0.02	-25
925.3	0.03	0.18	109.0	5.45	0.02	172
1000.0	0.03	0.17	108.8	5.15	0.02	108

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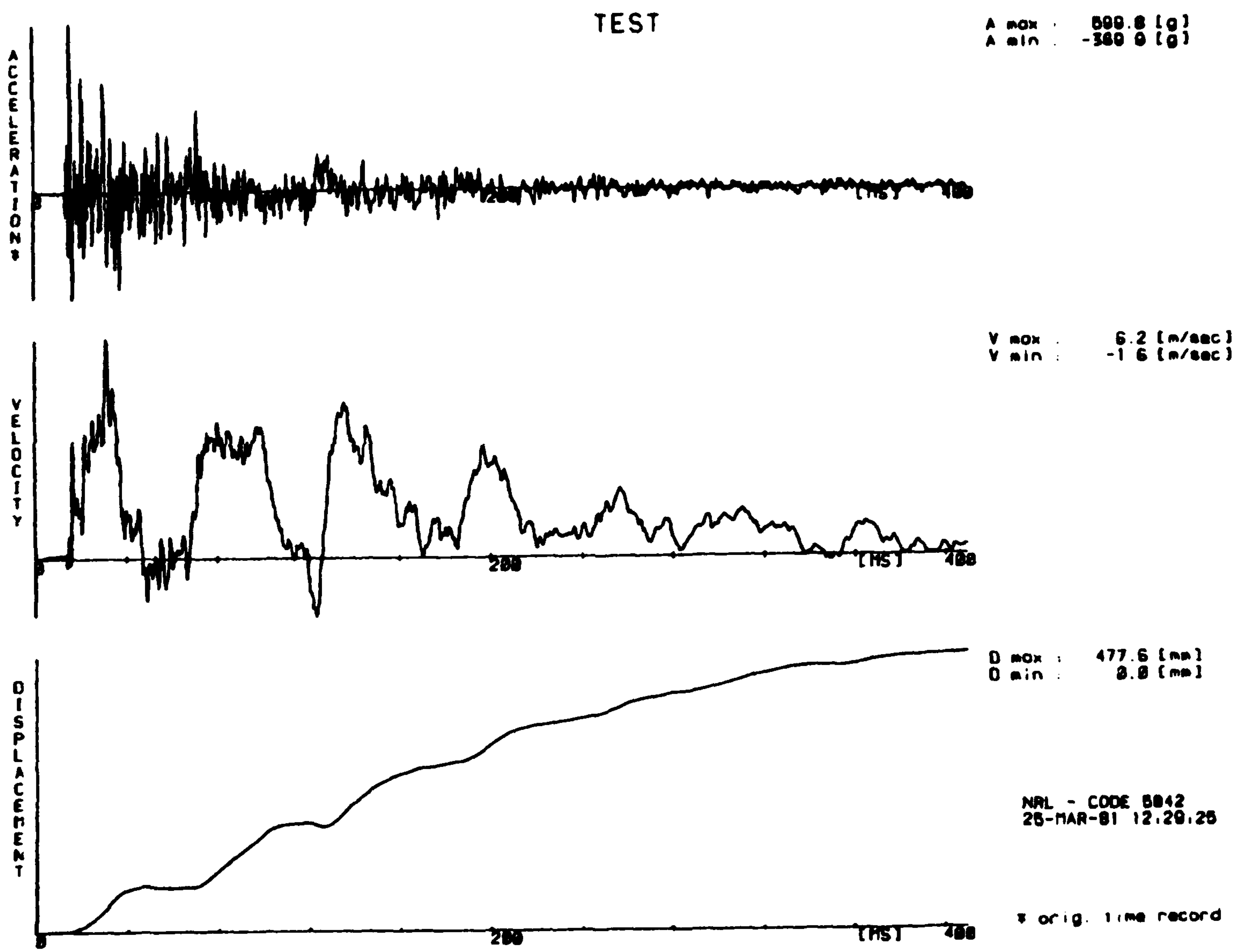
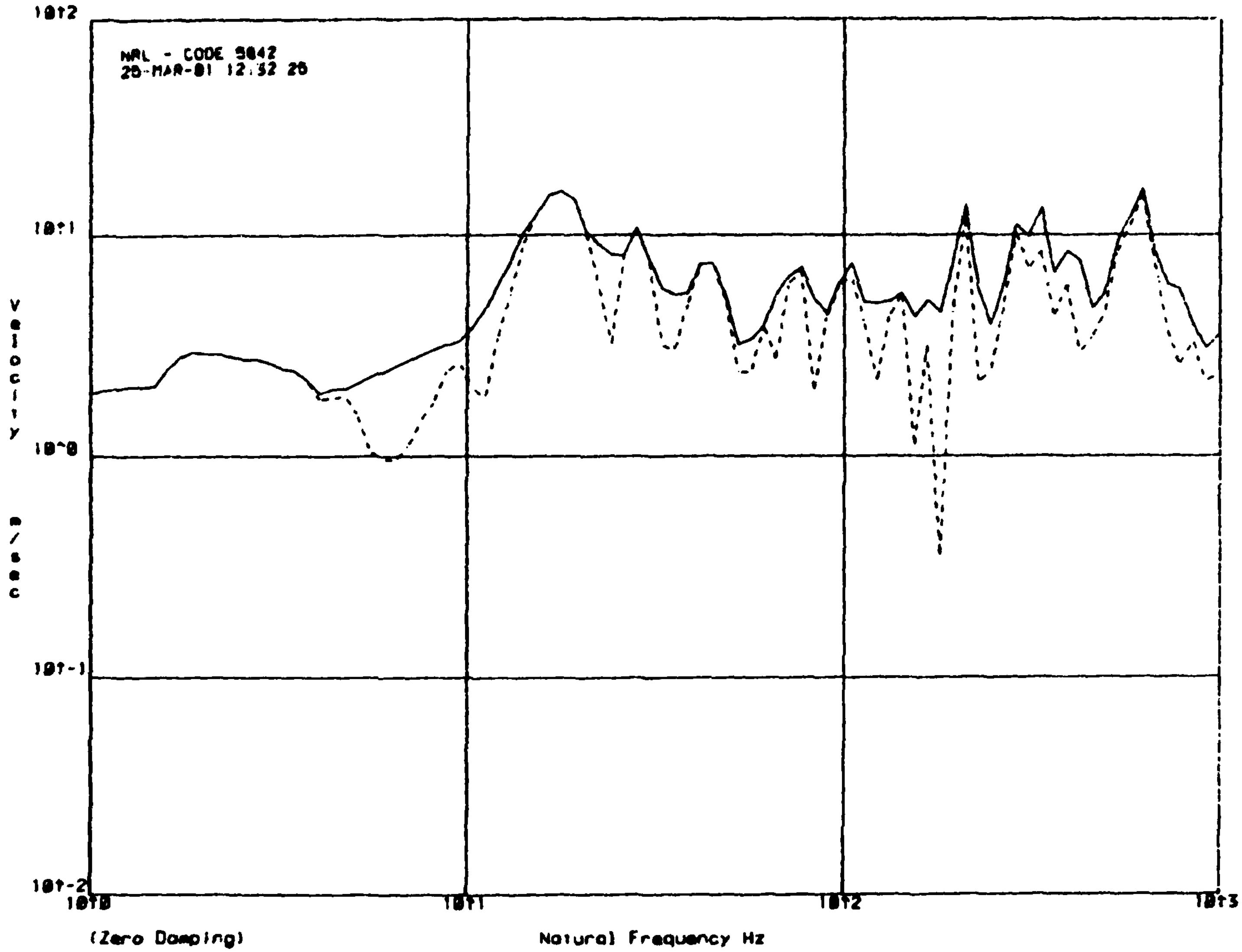
(e) Tabular listing of all computed data

Fig. 3 — Output for analysis of a half-sine acceleration pulse



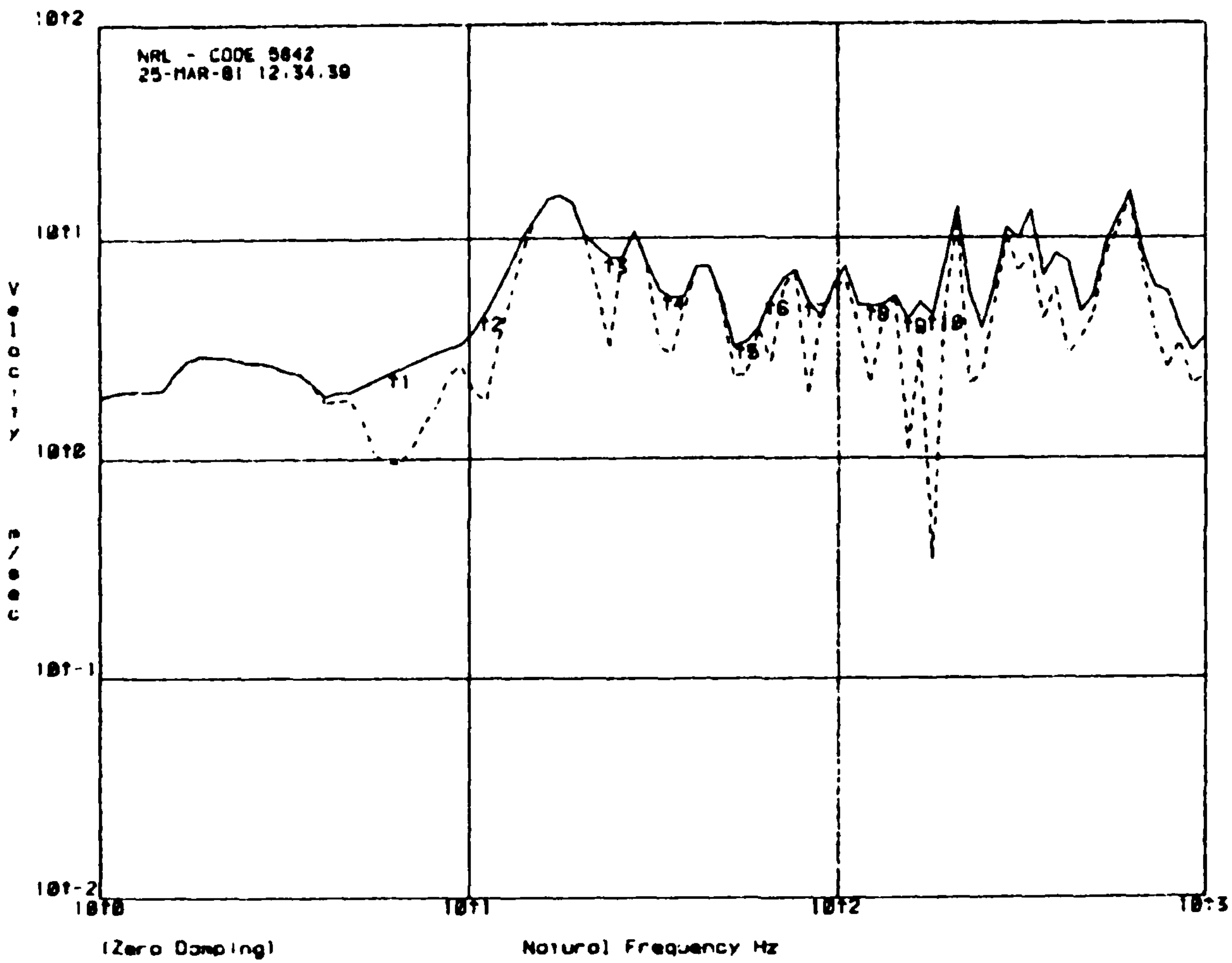
(a) Acceleration, velocity, and displacement time histories

Fig. 4 — Output for analysis of FSP acceleration record



(b) Maximax and residual shock spectra

Fig. 4 — Output for analysis of FSP aceeleration record



NR	[HZ]	[M/SEC]
↑ 1.	6 2	2 6
↑ 2.	10.9	4.6
↑ 3.	23.0	8 2
↑ 4.	34 2	5 6
↑ 5.	54.3	3 3
↑ 6.	65 5	5 3
↑ 7	83 7	5.1
↑ 8.	123 1	5 0
↑ 9	155.0	4.4
↑10.	181.1	4.5

(c) Maximax and residual shock spectra, analysis mode

Fig. 4 — Output for analysis of FSP acceleration record

TEST

FREQ (HZ)	(MM)	SHOCK SPECTRUM (M/S)	(G)	(MS)	FOURIER TRANS (M/S)	(DEG)
1.0	307.08	1.94	1.2	222.75	1.94	170
1.1	203.77	1.99	1.4	222.25	1.99	176
1.2	277.81	2.04	1.5	221.75	2.04	-177
1.3	260.14	2.06	1.7	220.25	2.06	-170
1.4	240.73	2.06	1.8	218.25	2.06	-163
1.5	225.07	2.08	2.0	177.25	2.08	-176
1.6	-247.73	-2.48	-2.5	418.75	-2.48	150
1.7	-261.20	-2.83	-3.1	418.75	-2.83	170
1.9	-255.00	-2.98	-3.6	418.75	-2.98	-170
2.0	-232.33	-2.94	-3.8	406.25	-2.94	-156
2.2	-214.88	-2.93	-4.1	368.75	-2.93	-162
2.3	-192.40	-2.84	-4.3	363.25	-2.84	-143
2.5	-173.53	-2.77	-4.5	318.25	-2.77	-159
2.7	-160.78	-2.77	-4.9	303.75	-2.77	-150
3.0	-142.82	-2.66	-5.1	297.75	-2.66	-132
3.2	-124.82	-2.51	-5.2	263.75	-2.51	-146
3.5	-113.12	-2.46	-5.5	256.25	-2.46	-131
3.7	-94.06	-2.21	-5.3	249.75	-2.21	-114
4.0	-76.06	-1.93	-5.0	202.25	-1.82	-104
4.4	-73.27	-2.01	-5.6	200.25	-1.84	-124
4.7	68.42	2.03	6.1	51.75	-1.87	-110
5.1	67.28	2.16	7.1	51.75	-1.56	-89
5.5	65.96	2.20	8.1	51.75	-1.05	-61
6.0	64.74	2.42	9.3	48.25	0.97	-152
6.4	63.62	2.57	10.6	48.25	0.96	-120
7.0	62.38	2.73	12.2	47.25	-1.12	167
7.5	61.00	2.80	13.9	47.25	1.45	-166
8.1	59.60	3.04	15.9	47.25	1.75	-139
8.8	57.90	3.20	18.0	47.25	-2.43	-177
9.5	55.95	3.34	20.3	47.25	-2.69	-139
10.3	-59.58	-3.84	-25.3	80.75	-2.04	-124
11.1	66.43	4.63	32.9	114.25	-1.84	172
12.0	70.64	5.92	45.5	112.25	-3.46	-149
13.0	-93.67	-7.62	-63.3	140.25	5.48	-163
14.0	-116.53	-10.25	-92.0	137.75	8.99	-137
15.1	130.44	12.40	120.3	163.75	12.40	-98
16.3	147.42	15.14	158.8	157.75	15.14	-62
17.7	143.42	15.92	180.4	152.25	15.92	-22
19.1	122.25	14.67	179.6	147.75	14.67	26
20.6	80.64	10.45	138.4	142.75	10.45	70
22.3	65.35	9.16	131.0	86.25	5.90	96
24.1	-54.49	-8.25	-127.5	104.25	-3.21	51
26.0	49.95	8.17	136.5	150.25	8.17	59
28.1	61.53	10.80	196.5	146.75	10.80	137
30.4	40.71	7.78	151.8	142.75	7.78	-147
32.9	-28.16	-5.82	-122.6	53.75	3.24	-157
35.5	-24.25	-5.41	-123.3	53.25	-3.91	-167
38.4	-22.74	-6.48	-135.1	103.25	-4.89	-131
41.5	-28.62	-7.46	-190.6	122.75	-7.46	-56
44.8	-26.61	-7.50	-216.6	119.25	-7.50	35
48.6	-17.74	-5.40	-167.9	116.25	5.11	150
52.4	-9.86	-3.25	-100.0	59.75	-2.40	-58
56.6	-9.56	-3.40	-123.6	59.75	-2.42	139
61.2	-10.16	-3.91	-163.2	114.75	-3.91	-83
66.1	-12.89	-5.36	-227.0	93.75	2.76	-12
71.4	14.69	6.69	302.1	83.75	5.99	71
77.2	-14.83	-7.20	-356.3	114.25	-7.20	-155
83.4	9.83	5.15	275.8	65.75	-1.97	-79
90.2	7.90	4.48	259.0	75.75	4.29	4
97.4	-9.97	-6.10	-381.4	99.25	5.96	165
105.3	11.35	7.51	507.2	82.15	-6.53	-33
113.8	7.03	5.03	367.1	79.65	4.11	116
123.0	-6.41	-4.95	-399.9	46.45	-2.22	140
132.9	-6.05	-5.05	-430.9	45.15	4.33	-86
143.6	-6.11	-5.51	-508.1	99.65	-5.51	23
155.2	-4.39	-4.29	-426.8	49.35	1.10	164
167.8	4.86	5.12	551.0	80.15	3.25	-108
181.3	3.97	4.53	526.5	32.05	-0.35	33
195.9	6.24	7.68	964.9	66.45	4.67	75
211.8	10.44	13.98	1887.3	78.95	-12.18	-14
228.8	-3.99	-5.73	-841.5	46.75	-2.17	82
247.3	2.56	3.98	631.7	38.85	-2.46	-139
267.3	-3.62	-6.09	-1043.4	46.85	-4.98	98
288.9	6.19	11.23	2080.3	82.55	10.37	32
312.2	5.10	10.88	2081.6	53.95	7.89	-16
337.4	-6.37	-13.58	-2920.9	57.15	8.59	28
364.6	2.97	6.81	1593.0	37.15	4.29	35
394.8	-3.45	-8.54	-2157.5	47.75	-6.12	-153
425.8	-2.91	-7.79	-2127.1	41.75	2.97	-101
460.2	-1.62	-4.78	-1386.6	29.45	3.49	-18
497.3	-1.77	-5.52	-1761.0	29.25	4.49	-108
537.4	-2.75	-9.27	-3196.3	69.75	-8.42	81
580.8	-3.38	-12.33	-4594.7	56.25	-18.97	167
627.7	4.15	16.36	6597.1	78.75	-15.84	-112
678.4	-2.02	-8.59	-3739.5	56.45	-7.75	19
733.1	-1.32	-6.10	-2868.9	45.65	-3.84	25
792.3	-1.16	-5.76	-2929.7	45.65	-2.60	-6
856.2	-0.74	-4.08	-2194.4	69.75	-3.40	146
925.3	-0.54	-3.11	-1847.5	48.65	2.21	-97
1000.0	-0.56	-3.55	-2274.2	48.55	-2.35	72

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(d) Tabular listing of all computed data

Fig. 4 — Output for analysis of FSP acceleration record

REFERENCES

1. E. W. Clements: "Shipboard Shock and Navy Devices for its Simulation," NRL 7396, July 14, 1972.

2. G. J. O'Hara: "Shock Spectra and Design Shock Spectra," NRL Report 5386, Nov. 1959.

3. E. W. Clements: "Characteristics of the Navy Large Floating Shock Platform," NRL Report 7761, July 15, 1974.

4. G. J. O'Hara: "A Numerical Procedure For Shock and Fourier Analysis," NRL Report 5772, June 1962.

5. R. L. Bort: "Shock Program 74G2", Rev. 1977.

Appendix 1

List of Program Variables

```
1:A   Array for time record DIM(N0)
2:A2  Zero offset - Matrix DIM(7,2)
3:B   Array DIM(2)
4:B3  Variable used in subroutine TIME
5:B4  Variable used in subroutine TIME
6:C   Array DIM(C0)
7:C0  Actual number of analysis frequencies (default 90)
8:C1  Element of F5 (first analysis frequency per frequency range)
9:C2  Element of F5 (last analysis frequency per frequency range)
10:C3 Max. possible analysis frequencies (depends on memory available)
11:D  I/O device address (default 32)
12:D1 File number on ext. tape drive to store data
13:D3 File number on ext. tape drive to read data from
14:E  Instantaneous factor for sample step
15:E1 Factor for sample step within frequency range I(1-10Hz)
16:E2 Factor for sample step within frequency range II(10-100Hz)
17:E3 Factor for sample step within frequency range III(100-1000Hz)
18:F  Instantaneous value of analysis frequency
19:F1 Lowest analysis frequency (default 1)
20:F2 Highest analysis frequency (default 1000)
21:F3 Lower analysis frequency within one of the 3 frequency ranges
22:F4 Upper analysis frequency within one of the 3 frequency ranges
23:F5 Frequency array DIM(C0)
24:F6 Lower frequency of lin. graph (input)
25:F7 Upper frequency of lin. graph (input)
26:F8 Cutoff frequency of lowpass filter
27:G  Instantaneous value of acceleration ((2*pi*F)↑2*X)
28:G5 Acceleration array DIM(C0)
29:H  Time increment of digitized time record
30:H1 Exponent
31:H2 Time increment for computation
32:I  Counter
33:I1 Counter to find C1
34:I2 Indicates frequency range (I to III)
35:I3 Sample number when V2 occurs
36:I4 Sample number when V1 occurs
37:K  Target array for graph display
38:K1 Factor of F8 to calculate sample frequency within frequency range I (d
   efault 2)
39:K2 Factor of F8 to calculate sample frequency within frequency range II (
   default 2)
40:K3 Factor of F8 to calculate sample frequency within frequency range III
   (default 10)
41:L  Calibration level in input units
42:M  Number of data module
43:M1 Maximum of array K for autoscale
44:M9 Calibration Matrix DIM(7,2)
45:N0 Number of data points on record (default 4096)
46:N  Number of data points considered during calculation
47:N1 Lower vertical level of log. graph display
48:N2 Upper vertical level of log. graph display
49:N4 Number of data points at the beginning of the residual response
50:N5 Number of data points after truncation
51:N6 Lower frequency of log. graph display
52:N7 Upper frequency of log. graph display
53:O  Indicates the part of the program currently loaded (1 or 2)
54:P  Selects grid on log. display (P>10 no grid, default 10)
```

```
55.P1 Error indicator if >0.902
56:Q  Number of periods considered per analysis frequency
57:R  Selects MAXIMAX- and/or RESIDUAL SHOCK SPECTRUM(keys 6 to 9)
58.R1 Selects div. linear spectra (user defined keys 16 to 20)
59 R2 Indicates displacement(1),velocity(2) or acceleration(3) record
60 R3 Equals X3 before N4 (initial)
61:R4 Equals X3 after N4 (residual)
62 R5 Flag for offset-procedure
63:R6 Flag for deleting calibration routine
64 R8 Flag in calibration routine
65:S  Calibration factor
66 S1 Calibration factor after differentiation and/or integration
67:S2 Calibration factor after E-procedure
68 T  Instantaneous value of time of maximum (T3 or T4)
69:T1 Beginning of time record
70:T3 Time of max. response before N4 (initial)
71:T4 Time of max. response after N4 (residual)
72 T5 Time array (contains max  values of either T3 or T4) DIM(C0)
73 U  Time difference in decimal value
74.V  Instantaneous value of pseudvelocity ((2*pi*F)*X)
75:V1 Maximum of array A
76 V2 Minimum of array A
77:V5 Velocity array DIM(C0)
78:W  Factor
79 W1 Number of spectra pro plot (Multi Display Mode) and flag for W$-displa
   y
80.W2 Array, DIM W2(W1)
81:X  X-coordinate of pointer
82 X  Instantaneous value of displacement (maximum of R3 or R4)
83:X1 Deflection at -0.5*H2
84:X2 Deflection at +0.5*H2
85:X3 Max. response of analysis frequency F
86:X5 Displacement array
87:Y  Y-coordinate of pointer
88 Y  Instantaneous value of of max. response velocity after N4
89:Y5 Velocity array DIM(C0)
90:Z  Instantaneous value of of phase
91:Z5 Phase array DIM(C0)
92:A$ String for graph display
93:B$ System time when process-procedure is completed
94:C$ Time string
95:D$ String to address data module
96:G$ String for graph display
97:H$ String for graph display
98 L$ String to check condition of data module
99 M$ String for graph display
100 N$ String for graph display
101 P$ String for graph display
102:Q$ String (if "0" stops analysis procedure)
103:R$ "NRL - CODE 5842"
104:T$ Contains system time
105:V$ Contains text for vert. level
106 W$ Title to identify record
107:X$ Segment string
108 Y$ Segment string
109 Z$ Segment string
```

Appendix 2

Program Listing

```
1 REM ////////////////////////// @SPRGM/PART I \\\\\\\\\\\\\\\\\\\\\\\\\\\
2 INIT
3 GO TO 260
4 IF O=1 THEN 92
5 GO TO 7450
8 IF O=1 THEN 92
9 GO TO 7530
12 IF O=1 THEN 92
13 GO TO 8980
16 GO TO 190
20 GO TO 100
24 IF O=1 THEN 92
25 R=1
26 GO TO 7690
28 IF O=1 THEN 92
29 R=2
30 GO TO 7690
32 IF O=1 THEN 92
33 R=3
34 GO TO 7690
36 IF O=1 THEN 92
37 GO TO 9510
40 IF O=1 THEN 92
41 GO TO 9780
44 IF O=2 THEN 90
45 CHARSIZE 3
46 IF R6=0 THEN 94
47 IF R6=1 THEN 4200
48 IF O=2 THEN 90
49 GO TO 530
50 DELETE A
52 IF O=2 THEN 90
53 GO TO 2510
54 DELETE A
56 IF O=2 THEN 90
57 GO TO 5250
60 IF O=2 THEN 90
61 R5=1
62 CHARSIZE 3
63 GO TO 2410
64 IF O=1 THEN 92
65 R1=1
66 GO TO 6010
68 IF O=1 THEN 92
69 R1=4
70 GO TO 6010
72 IF O=1 THEN 92
73 R1=2
74 GO TO 6010
76 IF O=1 THEN 92
77 R1=3
78 GO TO 6010
80 IF O=1 THEN 92
81 R1=5
82 GO TO 6010
90 PRINT "You got to PRESS KEY 5 first!G"
91 RETURN
92 PRINT "You got to PRESS KEY 4 first!G"
93 RETURN
94 PRI "LJJTHE CALIBRATION PROCEDURE HAS BEEN DELETED IN ORDER TO_SAVE";
```

```
95 PRINT " MEMORY.__IF YOU WANT TO REDEFINE THE CALIBRATION MATRIX M9 ";
96 PRINT "RELOAD_THE PROGRAM (PRESS USER DEFINED KEY 4 AND 5 IN A ROW"
97 PRINT "OR PRESS >AUTOLOAD<)!GG"
99 RETURN
100 REM *************** LOAD ROUTINE **********************************
110 IF O=1 THEN 160
120 DELETE F5,X5,V5,G5,T5,Y5,Z5,C,K,A
130 R6=1
140 O=1
150 APPEND "@SPRGM/PARTI";1
160 PRINT "LGSPRGM/PART I IS LOADED!"
170 DELETE 5380,20000
180 RETURN
190 IF O=2 THEN 240
200 O=2
210 DELETE 270,20000
220 APPEND "@SPRGM/PARTII";260
230 RENUMBER 6000,10,260
240 PRINT "LGSPRGM/PART II IS LOADED!"
250 RETURN
260 REM *************** DEFAULT CONDITION ******************************
270 W$="TEST"
280 O=1
290 W1=0
300 R5=0
310 R6=1
320 D=32
330 F1=1
340 F2=1000
350 F8=1000
360 N1=0.01
370 N2=100
380 N6=1
390 N7=1000
400 C0=90
410 N0=4096
420 K1=2
430 K2=2
440 K3=10
450 P=10
460 DIM M9(7,2),C(C0),A2(7,2),R$(15),T$(18),B$(18),C$(18)
470 DIM D$(8),H$(20),V$(22),G$(7),M$(7),N$(8),X$(22),P$(35),L$(4),Q$(1)
480 R$="NRL - CODE 5842"
490 M9=0
500 A2=0
510 PRINT "_GSPRGM/PART I IS LOADED (DEFAULT CONDITIONS)!"
520 RETURN
530 REM ****************** READ RECORD *********************************
540 DELETE 4200,5240
550 R6=0
560 PRINT @D,17:1.2,1.8
570 CHARSIZE 3
580 PRI "LTHE CURRENT TITLE IS '";W$;"' J_ENTER A NEW TITLE IF NECESSA";
590 PRINT "RY. OTHERWISE PRESS 'RETURN'.JG"
600 INPUT A$
610 IF A$="" THEN 630
620 W$=A$
630 DIM A(N0)
640 CHARSIZE 3
650 IF R5=0 THEN 660
```

```
660 W3=130
670 IF D<>4 THEN 690
680 W3=150
690 PRINT "JENTER NUMBER OF DATA MODULE TO READ FROM:G";
700 INPUT M
710 IF R5=1 THEN 740
720 IF M9(M,2)=0 THEN 2390
730 S=M9(M,2)
740 PRINT @6:"P"
750 GO TO M OF 760,780,800,820,840,860,880
760 D$="I01B4096"
770 GO TO 890
780 D$="I02B4096"
790 GO TO 890
800 D$="I03B4096"
810 GO TO 890
820 D$="I04B4096"
830 GO TO 890
840 D$="I05B4096"
850 GO TO 890
860 D$="I06B4096"
870 GO TO 890
880 D$="I07B4096"
890 PRINT @6:D$
900 INPUT @6:A
910 P$="D"
920 PRINT @6:P$
930 INPUT @6:P$
940 A=A-A2(M,2)
950 H$="SA"
960 PRINT @6:H$
970 INPUT @6:H$
980 H1=VAL(H$)
990 IF H1>12 THEN 1180
1000 GO TO H1 OF 1,1,1,1010,1030,1050,1070,1090,1110,1130,1150,1170
1010 H=0.005
1020 GO TO 1200
1030 H=0.01
1040 GO TO 1200
1050 H=0.025
1060 GO TO 1200
1070 H=0.05
1080 GO TO 1200
1090 H=0.1
1100 GO TO 1200
1110 H=0.25
1120 GO TO 1200
1130 H=0.5
1140 GO TO 1200
1150 H=1
1160 GO TO 1200
1170 H=2.5
1180 PRINT "ENTER TIME INCREMENT IN MS          ";
1190 INPUT H
1200 IF R5=1 THEN 2430
1210 CHARSIZE 2
1220 CALL "TIME",T$
1230 PRINT @D:"LK";R$
1240 PRINT @D:T$
1250 WINDOW 0,W3,0,100
```

```
1260 VIEWPORT 0,W3,0,100
1270 IF W1>0 THEN 1350
1280 PRINT @D,17:2,3
1290 CHARSIZE 4
1300 MOVE @D:W3/2,98
1310 FOR I=1 TO LEN(W$)/2
1320 PRINT @D:"H";
1330 NEXT I
1340 PRINT @D:W$
1350 PRINT @D,17:1.2,1.8
1360 CHARSIZE 2
1370 T1=H*ABS(VAL(P$))
1380 GO TO R2 OF 1390,1520,1660
1390 GOSUB 1840
1400 S1=S
1410 GOSUB 2020
1420 PRINT @D:"*"
1430 CALL "DIF3",A,A
1440 S1=S1/H
1450 GOSUB 1900
1460 GOSUB 2020
1470 CALL "DIF3",A,A
1480 S1=S1*10^3/(H*9.8044)
1490 GOSUB 1960
1500 GOSUB 2020
1510 GO TO 1780
1520 GOSUB 1900
1530 S1=S
1540 GOSUB 2020
1550 PRINT @D:"*"
1560 CALL "DIF3",A,A
1570 S1=S1*10^3/(9.8044*H)
1580 GOSUB 1960
1590 GOSUB 2020
1600 CALL "INT ",A,A
1610 CALL "INT ",A,A
1620 S1=S1*1.0E-3*H^2*9.8044
1630 GOSUB 1840
1640 GOSUB 2020
1650 GO TO 1780
1660 GOSUB 1960
1670 S1=S
1680 GOSUB 2020
1690 PRINT @D:"*"
1700 CALL "INT",A,A
1710 S1=S1*1.0E-3*H*9.8044
1720 GOSUB 1900
1730 GOSUB 2020
1740 CALL "INT",A,A
1750 S1=S1*H
1760 GOSUB 1840
1770 GOSUB 2020
1780 VIEWPORT 0,W3,0,100
1790 WINDOW 0,W3,0,100
1800 MOVE @D:0,0
1810 PRINT @D:"* orig. time record";
1820 DELETE A
1830 RETURN
1840 VIEWPORT 5,W3-30,4,32
1850 V$="DISPLACEMENT"
```

```
1860 G$="D max :"
1870 M$="D min :"
1880 N$=" [mm]"
1890 RETURN
1900 VIEWPORT 5,W3-30,36,64
1910 V$="VELOCITY"
1920 G$="V max :"
1930 M$="V min :"
1940 N$=" [m/sec]"
1950 RETURN
1960 VIEWPORT 5,W3-30,68,96
1970 V$="ACCELERATION"
1980 G$="A max :"
1990 M$="A min :"
2000 N$=" [g]"
2010 RETURN
2020 CALL "MAX",A,V1,I4
2030 CALL "MIN",A,V2,I3
2040 WINDOW 0,N0,V2,V1
2050 IF D=32 THEN 2110
2060 MOVE @D:0,0
2070 FOR I=1 TO N0
2080 DRAW @D:I,A(I)
2090 NEXT I
2100 GO TO 2120
2110 CALL "DISP",A
2120 AXIS @D:400,0
2130 IF R5=1 THEN 2340
2140 FOR I=0 TO N0 STEP 2000
2150 MOVE @D:I,0
2160 PRINT @D:"HJ",I*H;
2170 NEXT I
2180 PRINT @D:"HHHHHHHHHHH[MS]"
2190 MOVE @D:4200,V1
2200 PRINT @D: USING 2240:"J",G$,V1*S1,N$;
2210 MOVE @D:4200,V1
2220 PRINT @D:"J";
2230 PRINT @D: USING 2240:"J",M$,V2*S1,N$;
2240 IMAGE A,7A,6D.1D,11A
2250 MOVE @D:0,0.5*(V2+V1)
2260 PRINT @D:"HH";
2270 FOR I=1 TO LEN(V$)/2
2280 PRINT @D:"K";
2290 NEXT I
2300 FOR I=1 TO LEN(V$)
2310 X$=SEG(V$,I,1)
2320 PRINT @D:X$;"HJ";
2330 NEXT I
2340 RETURN
2350 PRINT @D:"JDATA MODULE ";M;" IS IN GROUND MODE !!GG"
2360 RETURN
2370 PRINT "JDATA MODULE ";M;" IS IN CALIBRATION MODE !!GG"
2380 RETURN
2390 PRINT "JREAD THE CALIBRATION STEP FIRST!G"
2400 RETURN
2410 PRINT "LOFFSET - CORRECTION:"
2420 GO TO 630
2430 VIEWPORT 0,110,10,90
2440 CALL "INT",A,A
2450 GOSUB 2020
```

```
2460 POINTER X,Y,Q$
2470 A2(M,1)=M
2480 A2(M,2)=Y/X+A2(M,2)
2490 R5=0
2500 RETURN
2510 REM ******************** PROCESS ***********************************
2520 CHARSIZE 3
2530 CALL "TIME",B$
2540 PRINT @D:"L";B$;"J"
2550 PRINT @32,26:2
2560 IF F1<1 THEN 2620
2570 IF F1>1000 THEN 2620
2580 IF F2<1 THEN 2630
2590 IF F2>1000 THEN 2630
2600 IF F2<=F1 THEN 2630
2610 GO TO 2660
2620 IF C0=1 THEN 2660
2630 PRI "ANALYSIS FREQUENCY IS OUT OF RANGE_ENTER NEW VALUES OF F1,F2G"
2640 INPUT F1,F2
2650 GO TO 2530
2660 DELETE F5,X5,V5,G5,T5,Y5,Z5,C,K,A
2670 DIM A(N0)
2680 C3=INT((MEMORY/8-18)/8)
2690 DIM F5(C0),X5(C0),V5(C0),G5(C0),T5(C0),Y5(C0),Z5(C0),C(C0)
2700 E1=INT(1000/(K1*F8*H))
2710 E2=INT(1000/(K2*F8*H))
2720 E3=INT(1000/(K3*F8*H))
2730 F5(1)=F1
2740 IF C0=1 THEN 2780
2750 FOR I=2 TO C0
2760 F5(I)=(F2/F1)^(1/(C0-1))*F5(I-1)
2770 NEXT I
2780 X5=0.01
2790 V5=0.01
2800 G5=0.01
2810 T5=0.01
2820 Y5=0.01
2830 Z5=0.01
2840 I1=1
2850 I2=0
2860 IF F1<10 THEN 2900
2870 I2=1
2880 IF F1<100 THEN 2900
2890 I2=2
2900 GO TO 3070
2910 E=E1
2920 GOSUB 3160
2930 IF I1>C0 THEN 3010
2940 GO TO 3070
2950 E=E2
2960 GOSUB 3160
2970 IF I1>C0 THEN 3010
2980 GO TO 3070
2990 E=E3
3000 GOSUB 3160
3010 DELETE A
3020 CALL "TIME",T$
3030 GOSUB 4030
3040 PRINT @32,26:0
3050 PRINT @D:"_MAX. POSSIBLE ANALYSIS FREQUENCIES: ";C3
```

```
3060 RETURN
3070 F3=F5(I1)
3080 C1=I1
3090 I2=I2+1
3100 FOR I1=1 TO C0
3110 IF F5(I1)>10^I2 THEN 3130
3120 NEXT I1
3130 F4=F5(I1-1)
3140 GO TO I2 OF 2910,2950,2990
3150 RETURN
3160 PRINT @6:"P";D$
3170 INPUT @6:A
3180 A=A-A2(M,2)
3190 IF E<=1 THEN 3260
3200 J=1
3210 FOR I=1 TO N0 STEP E
3220 A(J)=A(I)
3230 J=J+1
3240 NEXT I
3250 GO TO 3270
3260 E=1
3270 N5=N0/E
3280 H2=H*E
3290 GO TO R2 OF 3300,3340,3370
3300 CALL "DIF3",A,A
3310 CALL "DIF3",A,A
3320 S2=S
3330 GO TO 3380
3340 CALL "DIF3",A,A
3350 S2=S*H2
3360 GO TO 3380
3370 S2=S*10^-3*H2^2*9.8044
3380 C2=I1-1
3390 P1=0.0062831853*F3*H2
3400 FOR I=C1 TO C2
3410 C(I)=2*COS(P1)
3420 IF C1=C2 THEN 3440
3430 P1=P1*(F4/F3)^(1/(C2-C1))
3440 NEXT I
3450 IF P1<0.902 THEN 3500
3460 IF 143.566/H2>F2 THEN 3500
3470 PRINT "LGWARNING: FREQUENCIES ARE TOO HIGH FOR YOUR TIME INCREMENT"
3480 PRINT "          ERRORS ARE OUTSIDE THE RANGE -7 TO +3 PERCENT FOR"
3490 PRINT "          FREQUENCIES ABOVE ";143.566/H2;" HERTZ"
3500 FOR I=C1 TO C2
3510 F=F5(I)
3520 IF F<=1 THEN 3550
3530 N=1000/(H2*5*LGT(F))
3540 IF N<N5 THEN 3560
3550 N=N5
3560 X1=0
3570 X2=0
3580 R3=0
3590 R4=0
3600 IF F=0 THEN 3630
3610 N4=N-1-500/(F*H2)
3620 IF N4>3 THEN 3640
3630 N4=3
3640 FOR J=1 TO N-1
3650 X3=C(I)*X2-X1+A(J)
```

```
3660 IF J<N4 THEN 3710
3670 IF ABS(X3)<ABS(R4) THEN 3740
3680 R4=X3
3690 T4=J
3700 GO TO 3740
3710 IF ABS(X3)<ABS(R3) THEN 3740
3720 R3=X3
3730 T3=J
3740 X1=X2
3750 X2=X3
3760 NEXT J
3770 IF ABS(R3)>ABS(R4) THEN 3800
3780 R3=R4
3790 T3=T4
3800 X=S2*R3
3810 V=0.00628318*F*X
3820 G=6.288318*F*V/9.8044
3830 T=T1+(T3-0.5)*H2
3840 Y=0.00628318*F*S2*R4
3850 Z=1.0E-3*(T1+(T4-0.5)*H2)*F+0.25
3860 Z=Z-INT(Z)
3870 IF Y>0 THEN 3890
3880 Z=Z-0.5
3890 IF Z<=0.5 THEN 3910
3900 Z=Z-1
3910 Z=360*Z
3920 F5(I)=F
3930 X5(I)=X
3940 V5(I)=V
3950 G5(I)=G
3960 T5(I)=T
3970 Y5(I)=Y
3980 Z5(I)=Z
3990 PRINT @D: USING 4000:I,F,V,N;
4000 IMAGE 20T,3D,4X,4D.1D,4X,5D.2D,3X,6D
4010 NEXT I
4020 RETURN
4030 REM ****** SUBROUTINE TIME ***************************************
4040 DIM B(2)
4050 C$=B$
4060 FOR I=1 TO 2
4070 X$=SEG(C$,11,8)
4080 Y$=SEG(X$,4,2)
4090 Z$=SEG(X$,7,2)
4100 B(I)=VAL(X$)+(VAL(Y$)*60+VAL(Z$))/3600
4110 C$=T$
4120 NEXT I
4130 U=B(2)-B(1)
4140 B3=(U-INT(U))*60
4150 B4=(B3-INT(B3))*60
4160 PRINT @D:"__CALCULATION TIME (hr:min:sec):    ";
4170 PRINT @D: USING 4180:INT(U),":",INT(B3),":",INT(B4)
4180 IMAGE 2D,A,2D,A,2D
4190 RETURN
4200 REM *************** CALIBRATION ***********************************
4210 DIM A(N0)
4220 CHARSIZE 3
4230 PRINT "LARE YOU DEALING WITH_J   A DISPLACEMENT RECORD (MM)";
4240 PRINT " (ENTER 1) _    A VELOCITY RECORD (M/SEC)  (ENTER 2) _OR A";
4250 PRINT " ACCELERATION RECORD (G)  (ENTER 3)G         ";
```

```
4260 INPUT R2
4270 PRI "___DO YOU WANT__    TO READ A CALIBRATION STEP  (ENTER 1)_OR";
4280 PRINT " TO ENTER CALIBRATION FACTOR (ENTER 2)G        ";
4290 INPUT R8
4300 M9=0
4310 IF R8=2 THEN 4960
4320 FOR M=1 TO 7
4330 PRI "LENTER CALIBRATION LEVEL FOR CHANNEL ";M;" IN INPUT UNITSG:";
4340 INPUT L
4350 GOSUB 4750
4360 IF S4=0 THEN 4390
4370 IF S4=7 THEN 4420
4380 GO TO 4450
4390 GOSUB 2310
4400 CALL "WAIT",2
4410 GO TO 4730
4420 GOSUB 2330
4430 CALL "WAIT",2
4440 GO TO 4730
4450 PRINT @6:"P"
4460 GO TO M OF 4470,4490,4510,4530,4550,4570,4590
4470 D$="I01B4096"
4480 GO TO 4600
4490 D$="I02B4096"
4500 GO TO 4600
4510 D$="I03B4096"
4520 GO TO 4600
4530 D$="I04B4096"
4540 GO TO 4600
4550 D$="I05B4096"
4560 GO TO 4600
4570 D$="I06B4096"
4580 GO TO 4600
4590 D$="I07B4096"
4600 PRINT @6:D$
4610 INPUT @6:A
4620 WINDOW 0,5000,-512,512
4630 VIEWPORT 0,130,0,100
4640 PRINT "LCHANNEL ";M;"  JJSET CROSSHAIR TO UPPER CALIBRATION LEVELG"
4650 CALL "DISP",A
4660 AXIS
4670 POINTER X1,Y1,Q$
4680 PRINT "^JJJ             AND LOWER CALIBRATION LEVELG!"
4690 POINTER X2,Y2,Q$
4700 IF Y2>Y1 THEN 5230
4710 M9(M,1)=M
4720 M9(M,2)=L/(Y1-Y2)
4730 NEXT M
4740 RETURN
4750 GO TO M OF 4760,4780,4800,4820,4840,4860,4880
4760 L$="A01"
4770 GO TO 4890
4780 L$="A02"
4790 GO TO 4890
4800 L$="A03"
4810 GO TO 4890
4820 L$="A04"
4830 GO TO 4890
4840 L$="A05"
4850 GO TO 4890
```

```
4860 L$="A06"
4870 GO TO 4890
4880 L$="A07"
4890 PRINT @6:L$
4900 INPUT @6:L$
4910 S1=INT(VAL(L$)/1000)
4920 S2=INT((VAL(L$)-S1*1000)/100)
4930 S3=INT((VAL(L$)-S1*1000-S2*100)/10)
4940 S4=VAL(L$)-S1*1000-S2*100-S3*10
4950 RETURN
4960 PRINT "LENTER:"
4970 FOR M=1 TO 7
4980 GOSUB 4750
4990 IF S4=0 THEN 5020
5000 IF S4=7 THEN 5040
5010 GO TO 5060
5020 GOSUB 2310
5030 GO TO 5200
5040 GOSUB 2330
5050 GO TO 5200
5060 PRI "JCALIBRATION FACTOR (INPUT-UNITS/1VOLT) FOR CHANNEL ";M;": ";
5070 INPUT L
5080 GO TO S4 OF 5090,5110,5130,5150,5170,5190
5090 M9(M,2)=L/512
5100 GO TO 5200
5110 M9(M,2)=L*0.2/512
5120 GO TO 5200
5130 M9(M,2)=L*5/512
5140 GO TO 5200
5150 M9(M,2)=L*0.1/512
5160 GO TO 5200
5170 M9(M,2)=L*2/512
5180 GO TO 5200
5190 M9(M,2)=L*0.5/512
5200 M9(M,1)=M
5210 NEXT M
5220 RETURN
5230 PRINT "^JJJJJ      UPPER CALIBRATION LEVEL FIRST!! TRY IT AGAIN!!G"
5240 GO TO 4670
5250 REM *********************** WRITE RECORD *************************
5260 DIM A(N0)
5270 CHARSIZE 3
5280 PRINT "LENTER FILE NUMBER (DEVICE NR.3) TO WRITE RECORD ONG: ";
5290 INPUT D3
5300 FIND @3:D3
5310 PRINT @6:"P";D$
5320 INPUT @6:A
5330 A=A-A2(M,2)
5340 WRITE @3:W$,R2,H,T1,M,M9(M,2),A2(M,2),A
5350 PRINT "JRECORD IS STORED IN FILE #G";D3
5360 DELETE A
5370 RETURN


6000 REM                              SPRGM/PART II                       FILE 3
6010 REM *********************** LIN. SPECTRA *************************
6020 DELETE K
6030 DIM K(C0)
6040 A$="MAXIMAX SHOCK SPECTRUM"
6050 GO TO R1 OF 6060,6080,6100,6120,6150
```

```
6060 K=ABS(V5)
6070 GO TO 6170
6080 K=ABS(G5)
6090 GO TO 6170
6100 K=ABS(X5)
6110 GO TO 6170
6120 A$="RESIDUAL SHOCK SPECTRUM"
6130 K=ABS(Y5)
6140 GO TO 6170
6150 A$="PHASE"
6160 K=Z5
6170 CALL "MAX",K,M1,I4
6180 CHARSIZE 3
6190 PRINT "LJFREQUENCY RANGEG: ";
6200 INPUT F6,F7
6210 IF D=4 THEN 6240
6220 VIEWPORT 8*1.79,130-4*1.79,3*2.82,100-3*2.82
6230 GO TO 6260
6240 VIEWPORT 8*1.79,150-4*1.79,3*2.82,100-3*2.82
6250 PRINT @D,17:1.2,1.8
6260 CALL "TIME",T$
6270 CHARSIZE 1
6280 PRINT @D:"L";R$
6290 PRINT @D:T$
6300 IF R1=5 THEN 6510
6310 IF ABS(M1)<10 THEN 6350
6320 IF ABS(M1)<100 THEN 6390
6330 IF ABS(M1)<1000 THEN 6430
6340 IF ABS(M1)>1000 THEN 6470
6350 M1=INT(M1)+1
6360 WINDOW F6,F7,0,M1
6370 AXIS @D:(F7-F6)/10,0.5
6380 GO TO 6580
6390 M1=INT(M1/10)*10+10
6400 WINDOW F6,F7,0,M1
6410 AXIS @D:(F7-F6)/10,5
6420 GO TO 6580
6430 M1=INT(M1/100)*100+100
6440 WINDOW F6,F7,0,M1
6450 AXIS @D:(F7-F6)/10,50
6460 GO TO 6580
6470 M1=INT(M1/1000)*1000+1000
6480 WINDOW F6,F7,0,M1
6490 AXIS @D:(F7-F6)/10,500
6500 GO TO 6580
6510 WINDOW F6,F7,0,180
6520 AXIS @D:(F7-F6)/10,45
6530 MOVE @D:F6,180
6540 DRAW @D:F7,180
6550 DRAW @D:F7,0
6560 MOVE @D:(F7+F6)/2,180
6570 GO TO 6610
6580 MOVE @D:F6,M1
6590 DRAW @D:F7,M1
6600 DRAW @D:F7,0
6610 PRINT @D,17:2,3
6620 CHARSIZE 4
6630 GOSUB 6700
6640 IF W1>0 THEN 6800
6650 A$=W$
```

```
6660 PRINT @D,17:1.2,1.8
6670 CHARSIZE 2
6680 GOSUB 6700
6690 GO TO 6800
6700 IF R1=5 THEN 6730
6710 MOVE @D:(F7+F6)/2,M1
6720 GO TO 6740
6730 MOVE @D:(F7+F6)/2,180
6740 PRINT @D:"KK";
6750 FOR I=1 TO LEN(A$)/2
6760 PRINT @D:"H";
6770 NEXT I
6780 PRINT @D:A$;
6790 RETURN
6800 PRINT @D,17:1.2,2
6810 CHARSIZE 2
6820 H$="Natural Frequency Hz"
6830 MOVE @D:(F7+F6)/2,0
6840 PRINT @D:"JJJ";
6850 FOR I=1 TO LEN(H$)/2
6860 PRINT @D:"H";
6870 NEXT I
6880 PRINT @D:H$;
6890 GO TO R1 OF 6900,6940,6960,6920,6980
6900 V$="Pseudovelocity m/sec"
6910 GO TO 7010
6920 V$="Rel. Velocity m/sec"
6930 GO TO 7010
6940 V$="Abs. Acceleration g"
6950 GO TO 7010
6960 V$="Rel. Displacement mm"
6970 GO TO 7010
6980 V$=" Phase deg"
6990 MOVE @D:F6,90
7000 GO TO 7020
7010 MOVE @D:F6,0.5*INT(M1)
7020 PRINT @D:"HHHHHH";
7030 FOR I=1 TO LEN(V$)/2
7040 PRINT @D:"K";
7050 NEXT I
7060 FOR I=1 TO LEN(V$)
7070 X$=SEG(V$,I,1)
7080 PRINT @D:X$;"HJ";
7090 NEXT I
7100 FOR I=F6 TO F7 STEP (F7-F6)/10
7110 MOVE @D:I,0
7120 PRINT @D:"HJ";INT(I);
7130 NEXT I
7140 IF R1=5 THEN 7270
7150 IF ABS(M1)<=10 THEN 7190
7160 IF ABS(M1)<=100 THEN 7210
7170 IF ABS(M1)<=1000 THEN 7230
7180 IF ABS(M1)>1000 THEN 7250
7190 FOR I=0 TO ABS(M1) STEP 1
7200 GO TO 7280
7210 FOR I=0 TO ABS(M1) STEP 10
7220 GO TO 7280
7230 FOR I=0 TO ABS(M1) STEP 100
7240 GO TO 7280
7250 FOR I=0 TO ABS(M1) STEP 1000
```

```
7260 GO TO 7280
7270 FOR I=0 TO 180 STEP 45
7280 MOVE @D:F6,I
7290 PRINT @D:"HHH";I;
7300 NEXT I
7310 MOVE @D:F6,0
7320 PRINT @D,17:1,2
7330 A$="K(Zero Damping)"
7340 PRINT @D:"JJJJ";A$
7350 I=1
7360 FOR I=I TO C0
7370 IF F5(I)>0.01 THEN 7390
7380 NEXT I
7390 MOVE @D:F5(I),ABS(K(I))
7400 FOR I=I TO C0
7410 IF F5(I)=0.01 THEN 7360
7420 DRAW @D:F5(I),ABS(K(I))
7430 NEXT I
7440 RETURN
7450 REM ***************** WRITE DATA **********************************
7460 CHARSIZE 3
7470 PRINT "JLGENTER FILE NUMBER (DEVICE NR.3) TO WRITE DATA ON: ";
7480 INPUT D1
7490 FIND @3:D1
7500 WRITE @3:C0,W$,F5,X5,V5,G5,T5,Y5,Z5
7510 PRINT "RESULTS STORED IN FILEG #";D1
7520 RETURN
7530 REM ****************** READ DATA **********************************
7540 CHARSIZE 3
7550 PRINT "JLGENTER FILE NUMBER (DEVICE NR.3) TO READ DATA FROM: ";
7560 INPUT D3
7570 DELETE F5,X5,V5,G5,T5,Y5,Z5,K,A
7580 FIND @3:D3
7590 READ @3:C0
7600 FIND @3:D3
7610 DIM F5(C0),X5(C0),V5(C0),G5(C0),T5(C0),Y5(C0),Z5(C0),K(C0)
7620 READ @3:C0,W$,F5,X5,V5,G5,T5,Y5,Z5
7630 IF W1>0 THEN 7650
7640 PRINT "DATA ARE IN MEMORY!G"
7650 RETURN
7660 REM ********************** LOG. SPECTRA *********************
7670 VIEWPORT 5*1.79,110-4*1.79,10+3*2.82,100-3*2.82
7680 GO TO 7740
7690 VIEWPORT 8*1.79,130-4*1.79,3*2.82,100-3*2.82
7700 IF D=4 THEN 7720
7710 GO TO 7740
7720 VIEWPORT 8*1.79,150-4*1.79,3*2.82,100-3*2.82
7730 PRINT @D,17:1.2,1.8
7740 CHARSIZE 1
7750 DELETE K
7760 DIM K(C0)
7770 CALL "TIME",T$
7780 PRINT @D:"L";R$
7790 PRINT @D:T$;
7800 REM
7810 WINDOW LGT(N6),LGT(N7),LGT(N1),LGT(N2)
7820 IF P>10 THEN 7980
7830 H1=INT(LGT(N1))
7840 FOR I=10^H1 TO 10^(H1+1) STEP 10^H1*P
7850 MOVE @D:LGT(N6),LGT(I)
```

```
7860 DRAW @D:LGT(N7),LGT(I)
7870 NEXT I
7880 H1=H1+1
7890 IF H1<=LGT(N2) THEN 7840
7900 H1=LGT(N6)
7910 FOR I=10^H1 TO 10^(H1+1) STEP 10^H1*P
7920 MOVE @D:LGT(I),LGT(N1)
7930 DRAW @D:LGT(I),LGT(N2)
7940 NEXT I
7950 H1=H1+1
7960 IF H1<=LGT(N7) THEN 7910
7970 GO TO 8020
7980 AXIS @D:1,1,0,-2
7990 MOVE @D:LGT(N6),LGT(N2)
8000 DRAW @D:LGT(N7),LGT(N2)
8010 DRAW @D:LGT(N7),LGT(N1)
8020 PRINT @D,17:2,3
8030 CHARSIZE 4
8040 GO TO R OF 8050,8070,8090
8050 A$="MAXIMAX SHOCK SPECTRUM"
8060 GO TO 8100
8070 A$="RESIDUAL SHOCK SPECTRUM"
8080 GO TO 8100
8090 A$="MAXIMAX and RESIDUAL SHOCK SPECTRUM"
8100 GOSUB 8170
8110 IF W1>0 THEN 8240
8120 A$=W$
8130 PRINT @D,17:1.2,1.8
8140 CHARSIZE 2
8150 GOSUB 8170
8160 GO TO 8240
8170 MOVE @D:LGT(10^(0.5*LGT(N6*N7))),LGT(N2)
8180 PRINT @D:"KK";
8190 FOR I=1 TO LEN(A$)/2
8200 PRINT @D:"H";
8210 NEXT I
8220 PRINT @D:A$;
8230 RETURN
8240 GO TO R OF 8250,8270,8290
8250 V$="Pseudovelocity   m/sec"
8260 GO TO 8300
8270 V$="Rel. Velocity   m/sec"
8280 GO TO 8300
8290 V$="Velocity    m/sec"
8300 MOVE @D:LGT(N6),LGT(10^(0.5*LGT(N2*N1)))
8310 PRINT @D,17:1.5,2.5
8320 CHARSIZE 2
8330 PRINT @D:"HHHHHHH";
8340 FOR I=1 TO LEN(V$)/2
8350 PRINT @D:"K";
8360 NEXT I
8370 FOR I=1 TO LEN(V$)
8380 X$=SEG(V$,I,1)
8390 PRINT @D:X$;"HJ";
8400 NEXT I
8410 MOVE @D:LGT(10^(0.5*LGT(N6*N7))),LGT(N1)
8420 H$="Natural Frequency Hz"
8430 FOR I=1 TO LEN(H$)/2
8440 PRINT @D:"H";
8450 NEXT I
```

```
8460 PRINT @D:"JJJ",H$;
8470 H1=0
8480 FOR I=LGT(N1) TO LGT(N2) STEP 10^H1
8490 MOVE @D:LGT(N6),I
8500 PRINT @D:"HHHHH";"10^";INT(H1+LGT(N1))
8510 H1=H1+1
8520 NEXT I
8530 H1=0
8540 FOR I=LGT(N6) TO LGT(N7) STEP 10^H1
8550 MOVE @D:I,LGT(N1)
8560 PRINT @D:"HHJ";"10^";INT(H1+LGT(N6))
8570 H1=H1+1
8580 NEXT I
8590 MOVE @D:LGT(N6),LGT(N1)
8600 IF D=32 THEN 8620
8610 PRINT @D,17:1,2
8620 CHARSIZE 2
8630 A$="(Zero Damping)"
8640 PRINT @D:"JJJ";A$
8650 GOSUB 8770
8660 GOSUB 8820
8670 IF R=3 THEN 8690
8680 RETURN
8690 R=R+1
8700 IF D<>4 THEN 8740
8710 PRINT "LYOU MAY CHANGE THE PEN COLOR G";
8720 PRINT "_Press RETURN to continue"
8730 INPUT A$
8740 GOSUB 8770
8750 GOSUB 8820
8760 RETURN
8770 GO TO R OF 8780,8800,8780,8800
8780 K=V5
8790 GO TO 8810
8800 K=Y5
8810 RETURN
8820 I=1
8830 FOR I=I TO C0
8840 IF F5(I)>0.01 THEN 8870
8850 NEXT I
8860 RETURN
8870 MOVE @D:LGT(F5(I)),LGT(ABS(K(I)))
8880 FOR I=I TO C0
8890 IF F5(I)=0.01 THEN 8830
8900 IF R<=3 THEN 8920
8910 DASH 170
8920 DRAW @D:LGT(F5(I)),LGT(ABS(K(I)))
8930 NEXT I
8940 IF W1>0 THEN 8960
8950 DASH 0
8960 HOME
8970 RETURN
8980 REM ************** NUMERICAL OUTPUT ******************************
8990 WINDOW 0,130,0,100
9000 VIEWPORT 0,130,0,100
9010 I1=0
9020 I2=1
9030 N=1
9040 IF D=32 THEN 9070
9050 IF D=40 THEN 9130
```

```
9060 PRINT @D,17:1.5,2.5
9070 CHARSIZE 3
9080 PRINT @D:"L"
9090 MOVE @D:65,99
9100 FOR I=1 TO LEN(W$)/2
9110 PRINT @D:"H";
9120 NEXT I
9130 PRINT @D:W$
9140 CHARSIZE 1
9150 CALL "TIME",T$
9160 PRINT @D:"^J";R$,"_";T$,"JJ"
9170 IF D=40 THEN 9190
9180 PRINT @D: USING 9190:"KKK";"PAGE";I2;"JJ"
9190 IMAGE 3A,122X,4A,2D,2A
9200 CHARSIZE 2
9210 PRINT @D:"  FREQ            SHOCK SPECTRUM          FOURIER TRANS"
9220 PRINT @D:"  (HZ)     (MM)     (M/S)      (G)    (MS)     (M/S) (DEG)_"
9230 IMAGE 4D.1D,X,5D.2D,X,4D.2D,X,5D.1D,X,4D.2D,X,4D.2D,2X,4D
9240 IMAGE 65T,4D.1D,X,5D.2D,X,4D.2D,X,5D.1D,X,4D.2D,X,4D.2D,2X,4D
9250 FOR I=1+I1 TO C0
9260 IF I>50*N THEN 9300
9270 PRINT @D: USING 9230:F5(I),X5(I),V5(I),G5(I),T5(I),Y5(I),Z5(I)
9280 NEXT I
9290 RETURN
9300 IF D=40 THEN 9350
9310 CHARSIZE 1
9320 PRINT @D:"^JJJJJ"
9330 CHARSIZE 2
9340 PRINT @D:"J"
9350 FOR I=1+50*N TO C0
9360 IF I>(N+1)*50 THEN 9430
9370 IF D=40 THEN 9400
9380 PRINT @D: USING 9240:F5(I),X5(I),V5(I),G5(I),T5(I),Y5(I),Z5(I)
9390 GO TO 9410
9400 PRINT @D: USING 9230:F5(I),X5(I),V5(I),G5(I),T5(I),Y5(I),Z5(I)
9410 NEXT I
9420 RETURN
9430 IF D=40 THEN 9450
9440 CALL "WAIT",4
9450 I1=100
9460 I2=I2+1
9470 N=N+2
9480 IF D=40 THEN 9500
9490 GO TO 9040
9500 GO TO 9250
9510 REM ********************* ANALYSIS **********************************
9520 R=3
9530 GOSUB 7670
9540 R=1
9550 MOVE @D:3.11,2
9560 PRINT @D: USING "2A,5X,4A,3X,7A":"NR","[HZ]","[M/SEC]"
9570 POINTER X,Y,Q$
9580 IF Q$="0" THEN 9750
9590 MOVE @D:X-LGT(1.022),Y+LGT(1.022)
9600 CHARSIZE 2
9610 PRINT @D:"J^";R
9620 GOSUB 9650
9630 R=R+1
9640 GO TO 9570
9650 VIEWPORT 106,130,0,100
```

```
9660 WINDOW 0,32,0,100
9670 MOVE @D:0,94
9680 FOR I=1 TO R
9690 PRINT @D:"JJ";
9700 NEXT I
9710 PRINT @D: USING 9720:"J^",R,":",10^X,10^Y
9720 IMAGE 2A,2D,A,2X,4D.1D,3X,3D.D
9730 VIEWPORT 5*1.79,110-4*1.79,10+3*2.82,100-3*2.82
9740 WINDOW LGT(N6),LGT(N7),LGT(N1),LGT(N2)
9750 DASH 0
9760 HOME
9770 RETURN
9780 REM ********************* MULTI DISPLAY ***************************
9790 CHARSIZE 3
9800 D=32
9810 PRINT "LJENTER NUMBER OF DESIRED SPECTRAG: ";
9820 INPUT W1
9830 DIM W2(W1)
9840 PRINT "_ENTER FILE NUMBERS ON DEVICE NR.3G: ";
9850 INPUT W2
9860 PRINT "_ENTER:__1 FOR MAXIMAX-SPECTRA_2 FOR RESIDUAL-SPECTRAG: ";
9870 INPUT R
9880 D3=W2(1)
9890 GOSUB 7570
9900 GOSUB 7690
9910 GOSUB 10060
9920 IF W1=1 THEN 10050
9930 FOR I0=2 TO W1
9940 D3=W2(I0)
9950 GOSUB 7570
9960 DASH 11*I0
9970 GOSUB 8770
9980 GOSUB 8820
9990 GOSUB 10060
10000 NEXT I0
10010 DASH 0
10020 W1=0
10030 DELETE W2,X,Y,I0,D3,Q$
10040 W$="TEST"
10050 RETURN
10060 POINTER X,Y,Q$
10070 MOVE @D:X,Y
10080 DRAW @D:X+0.25,Y
10090 PRINT @D:" ";W$
10100 RETURN
```

```
1 REM ///////////////// @SPRGM/PART III \\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
2 INIT
3 GO TO 260
4 IF O=3 THEN 94
5 GO TO 7450
8 IF O=3 THEN 94
9 GO TO 7530
12 IF O=3 THEN 94
13 GO TO 8980
16 GO TO 190
20 GO TO 100
24 IF O=3 THEN 94
25 R=1
26 GO TO 7690
28 IF O=3 THEN 94
29 R=2
30 GO TO 7690
32 IF O=3 THEN 94
33 R=3
34 GO TO 7690
36 IF O=3 THEN 94
37 GO TO 9510
40 IF O=3 THEN 94
41 GO TO 9780
45 RETURN
48 IF O=2 THEN 90
49 GO TO 510
50 DELETE A
52 IF O=2 THEN 90
53 GO TO 1780
54 DELETE A
64 IF O=3 THEN 94
65 R1=1
66 GO TO 6010
68 IF O=3 THEN 94
69 R1=4
70 GO TO 6010
72 IF O=3 THEN 94
73 R1=2
74 GO TO 6010
76 IF O=3 THEN 94
77 R1=3
78 GO TO 6010
80 IF O=3 THEN 94
81 R1=5
82 GO TO 6010
90 PRINT "You got to PRESS KEY 5 first!G"
92 RETURN
94 PRINT "You got to PRESS KEY 4 first!G"
96 RETURN
100 REM**************** LOAD ROUTINE ***********************************
110 IF O=3 THEN 170
120 DELETE F5,X5,V5,G5,T5,Y5,Z5,C,C0,K,A
130 C0=90
140 O=3
150 APPEND "@SPRGM/PARTIII";1
160 PRINT "JGSPRGM/PART III IS LOADED!"
170 DELETE 5140,20000
180 RETURN
```

```
190 IF O=2 THEN 240
200 O=2
210 DELETE 270,20000
220 APPEND "@SPRGM/PARTII";260
230 RENUMBER 6000,10,260
240 PRINT "JGSPRGM/PART II IS LOADED!"
250 RETURN
260 REM************** DEFAULT CONDITION ********************************
270 W$="TEST"
280 O=3
290 W1=0
300 D=32
310 F1=1
320 F2=1000
330 F8=1000
340 N1=0.01
350 N2=100
360 N6=1
370 N7=1000
380 C0=90
390 N0=4096
400 K1=2
410 K2=2
420 K3=10
430 P=10
440 R$="NRL - CODE 5842"
450 DIM M9(7,2),A2(7,2),C(C0)
460 M9=0
470 A2=0
480 DIM D$(8),H$(20),V$(22),G$(7),M$(7),N$(8),X$(22),P$(35),L$(4),Q$(1)
490 PRINT "_GSPRGM/PART III IS LOADED (DEFAULT CONDITIONS)!"
500 RETURN
510 REM **************** READ RECORD************************************
520 CHARSIZE 3
530 PRINT "LJENTER FILE NUMBER (ON DEVICE 3) TO READ RECORD FROMG: ";
540 INPUT D1
550 DIM A(N0)
560 W3=130
570 IF D<>4 THEN 600
580 W3=150
590 PRINT @D,17:1.2,1.8
600 CHARSIZE 2
610 CALL "TIME",T$
620 PRINT @D:"LK",R$
630 PRINT @D:T$
640 FIND @3:D1
650 READ @3:W$,R2,H,T1,M
660 FIND @3:D1
670 READ @3:W$,R2,H,T1,M,M9(M,2),A2(M,2),A
680 M9(M,1)=M
690 A2(M,1)=M
700 S=M9(M,2)
710 WINDOW 0,W3,0,100
720 VIEWPORT 0,W3,0,100
730 IF W1>0 THEN 810
740 PRINT @D,17:2,3
750 CHARSIZE 4
760 MOVE @D:W3/2,98
770 FOR I=1 TO LEN(W$)/2
780 PRINT @D:"H";
```

```
790 NEXT I
800 PRINT @D:W$
810 PRINT @D,17:1.2,1.8
820 CHARSIZE 2
830 GO TO R2 OF 840,970,1110
840 GOSUB 1280
850 S1=S
860 GOSUB 1460
870 PRINT @D:"*"
880 CALL "DIF3",A,A
890 S1=S1/H
900 GOSUB 1340
910 GOSUB 1460
920 CALL "DIF3",A,A
930 S1=S1*10^3/(H*9.8044)
940 GOSUB 1400
950 GOSUB 1460
960 GO TO 1230
970 GOSUB 1340
980 S1=S
990 GOSUB 1460
1000 PRINT @D:"*"
1010 CALL "INT",A,A
1020 S1=S1*H
1030 GOSUB 1280
1040 GOSUB 1460
1050 CALL "DIF3",A,A
1060 CALL "DIF3",A,A
1070 S1=S1*10^3/(H^2*9.8044)
1080 GOSUB 1400
1090 GOSUB 1460
1100 GO TO 1230
1110 GOSUB 1400
1120 S1=S
1130 GOSUB 1460
1140 PRINT @D:"*"
1150 CALL "INT",A,A
1160 S1=S1*1.0E-3*H*9.8044
1170 GOSUB 1340
1180 GOSUB 1460
1190 CALL "INT",A,A
1200 S1=S1*H
1210 GOSUB 1280
1220 GOSUB 1460
1230 VIEWPORT 0,W3,0,100
1240 WINDOW 0,W3,0,100
1250 MOVE @D:0,0
1260 PRINT @D:"* orig. time record";
1270 RETURN
1280 VIEWPORT 5,W3-30,4,32
1290 V$="DISPLACEMENT"
1300 G$="D max :"
1310 M$="D min :"
1320 N$=" [mm]"
1330 RETURN
1340 VIEWPORT 5,W3-30,36,64
1350 V$="VELOCITY"
1360 G$="V max :"
1370 M$="V min :"
1380 N$=" [m/sec]"
```

```
1390 RETURN
1400 VIEWPORT 5,W3-30,68,96
1410 V$="ACCELERATION"
1420 G$="A max  :"
1430 M$="A min  :"
1440 N$=" [g]"
1450 RETURN
1460 CALL "MAX",A,V1,I4
1470 CALL "MIN",A,V2,I3
1480 WINDOW 0,N0,V2,V1
1490 IF D=32 THEN 1550
1500 MOVE @D:0,0
1510 FOR I=1 TO N0
1520 DRAW @D:I,A(I)
1530 NEXT I
1540 GO TO 1560
1550 CALL "DISP",A
1560 AXIS @D:400,0
1570 FOR I=0 TO N0 STEP 2000
1580 MOVE @D:I,0
1590 PRINT @D:"HJ",I*H;
1600 NEXT I
1610 PRINT @D:"HHHHHHHHHHH[MS]"
1620 MOVE @D:4200,V1
1630 PRINT @D: USING 1670:"J",G$,V1*S1,N$;
1640 MOVE @D:4200,V1
1650 PRINT @D:"J";
1660 PRINT @D: USING 1670:"J",M$,V2*S1,N$;
1670 IMAGE A,7A,6D.1D,11A
1680 MOVE @D:0,0.5*(V2+V1)
1690 PRINT @D:"HH";
1700 FOR I=1 TO LEN(V$)/2
1710 PRINT @D:"K";
1720 NEXT I
1730 FOR I=1 TO LEN(V$)
1740 X$=SEG(V$,I,1)
1750 PRINT @D:X$;"HJ";
1760 NEXT I
1770 RETURN
1780 REM ******************* PROCESS **********************************
1790 CHARSIZE 3
1800 CALL "TIME",B$
1810 PRINT @D:"L";B$;"J"
1820 PRINT @32,26:2
1830 IF F1<1 THEN 1890
1840 IF F1>1000 THEN 1890
1850 IF F2<1 THEN 1900
1860 IF F2>1000 THEN 1900
1870 IF F2<=F1 THEN 1900
1880 GO TO 1930
1890 IF C0=1 THEN 1930
1900 PRI "ANALYSIS FREQUENCY IS OUT OF RANGE_ENTER NEW VALUES OF F1,F2G"
1910 INPUT F1,F2
1920 GO TO 1800
1930 DELETE F5,X5,V5,G5,T5,Y5,Z5,C,K,A
1940 DIM A(N0)
1950 C3=INT((MEMORY/8-18)/8)
1960 DIM F5(C0),X5(C0),V5(C0),G5(C0),T5(C0),Y5(C0),Z5(C0),C(C0)
1970 FIND @3:D1
1980 READ @3:W$,R2,H,T1,M,S
```

```
1990 FIND @3:D1
2000 E1=INT(1000/(K1*F8*H))
2010 E2=INT(1000/(K2*F8*H))
2020 E3=INT(1000/(K3*F8*H))
2030 F5(1)=F1
2040 IF C0=1 THEN 2080
2050 FOR I=2 TO C0
2060 F5(I)=(F2/F1)^(1/(C0-1))*F5(I-1)
2070 NEXT I
2080 X5=0.01
2090 V5=0.01
2100 G5=0.01
2110 T5=0.01
2120 Y5=0.01
2130 Z5=0.01
2140 I1=1
2150 I2=0
2160 IF F1<10 THEN 2200
2170 I2=1
2180 IF F1<100 THEN 2200
2190 I2=2
2200 GO TO 2370
2210 E=E1
2220 GOSUB 2460
2230 IF I1>C0 THEN 2310
2240 GO TO 2370
2250 E=E2
2260 GOSUB 2460
2270 IF I1>C0 THEN 2310
2280 GO TO 2370
2290 E=E3
2300 GOSUB 2460
2310 DELETE A
2320 CALL "TIME",T$
2330 GOSUB 3320
2340 PRINT @32,26:0
2350 PRINT @D:"_MAX. POSSIBLE ANALYSIS FREQUENCIES: ";C3
2360 RETURN
2370 F3=F5(I1)
2380 C1=I1
2390 I2=I2+1
2400 FOR I1=1 TO C0
2410 IF F5(I1)>10^I2 THEN 2430
2420 NEXT I1
2430 F4=F5(I1-1)
2440 GO TO I2 OF 2210,2250,2290
2450 RETURN
2460 READ @3:W$,R2,H,T1,M,S,A2(M,2),A
2470 FIND @3:D1
2480 IF E<=1 THEN 2550
2490 J=1
2500 FOR I=1 TO N0 STEP E
2510 A(J)=A(I)
2520 J=J+1
2530 NEXT I
2540 GO TO 2560
2550 E=1
2560 N5=N0/E
2570 H2=H*E
2580 GO TO R2 OF 2590,2630,2660
```

```
2590 CALL "DIF3",A,A
2600 CALL "DIF3",A,A
2610 S2=S
2620 GO TO 2670
2630 CALL "DIF3",A,A
2640 S2=S*H2
2650 GO TO 2670
2660 S2=S*10^-3*H2^2*9.8044
2670 C2=I1-1
2680 P1=0.0062831853*F3*H2
2690 FOR I=C1 TO C2
2700 C(I)=2*COS(P1)
2710 IF C1=C2 THEN 2730
2720 P1=P1*(F4/F3)^(1/(C2-C1))
2730 NEXT I
2740 IF P1<0.902 THEN 2790
2750 IF 143.566/H2>F2 THEN 2790
2760 PRINT "LGWARNING: FREQUENCIES ARE TOO HIGH FOR YOUR TIME INCREMENT"
2770 PRINT "          ERRORS ARE OUTSIDE THE RANGE -7 TO +3 PERCENT FOR"
2780 PRINT "          FREQUENCIES ABOVE ";143.566/H2;" HERTZ"
2790 FOR I=C1 TO C2
2800 F=F5(I)
2810 IF F<=1 THEN 2840
2820 N=1000/(H2*5*LGT(F))
2830 IF N<N5 THEN 2850
2840 N=N5
2850 X1=0
2860 X2=0
2870 R3=0
2880 R4=0
2890 IF F=0 THEN 2920
2900 N4=N-1-500/(F*H2)
2910 IF N4>3 THEN 2930
2920 N4=3
2930 FOR J=1 TO N-1
2940 X3=C(I)*X2-X1+A(J)
2950 IF J<N4 THEN 3000
2960 IF ABS(X3)<ABS(R4) THEN 3030
2970 R4=X3
2980 T4=J
2990 GO TO 3030
3000 IF ABS(X3)<ABS(R3) THEN 3030
3010 R3=X3
3020 T3=J
3030 X1=X2
3040 X2=X3
3050 NEXT J
3060 IF ABS(R3)>ABS(R4) THEN 3090
3070 R3=R4
3080 T3=T4
3090 X=S2*R3
3100 V=0.00628318*F*X
3110 G=6.288318*F*V/9.8044
3120 T=T1+(T3-0.5)*H2
3130 Y=0.00628318*F*S2*R4
3140 Z=1.0E-3*(T1+(T4-0.5)*H2)*F+0.25
3150 Z=Z-INT(Z)
3160 IF Y>0 THEN 3180
3170 Z=Z-0.5
3180 IF Z<=0.5 THEN 3200
```

```
3190 Z=Z-1
3200 Z=360*Z
3210 F5(I)=F
3220 X5(I)=X
3230 V5(I)=V
3240 G5(I)=G
3250 T5(I)=T
3260 Y5(I)=Y
3270 Z5(I)=Z
3280 PRINT @D: USING 3290:I,F,V,N;
3290 IMAGE 20T,3D,4X,4D.1D,4X,5D.2D,3X,6D
3300 NEXT I
3310 RETURN
3320 REM ****** SUBROUTINE TIME **************************************
3330 DIM B(2)
3340 C$=B$
3350 FOR I=1 TO 2
3360 X$=SEG(C$,11,8)
3370 Y$=SEG(X$,4,2)
3380 Z$=SEG(X$,7,2)
3390 B(I)=VAL(X$)+(VAL(Y$)*60+VAL(Z$))/3600
3400 C$=T$
3410 NEXT I
3420 U=B(2)-B(1)
3430 B3=(U-INT(U))*60
3440 B4=(B3-INT(B3))*60
3450 PRINT @D:"__CALCULATION TIME (hr:min:sec):    ";
3460 PRINT @D: USING 3470:INT(U),":",INT(B3),":",INT(B4)
3470 IMAGE 2D,A,2D,A,2D
3480 RETURN
5000 REM ------------------------------------------------------------
5010 REM ------------------------------------------------------------
5020 REM    THIS PROCEDURE MAY BE USED TO CALCULATE SHOCK SPECTRA OF
5030 REM    TIME RECORDS STORED ON EXT. TAPE (FILE 1 TO 7) AND TO STORE
5040 REM    THE ACCORDING DATA ON INT. TAPE (FILE * TO FILE *+7).
5050 FOR D1=1 TO 7
5060 GOSUB 52
5070 N=D1+0
5080 FIND N
5090 MARK 1,7000
5100 FIND N
5110 WRITE C0,W$,F5,X5,V5,G5,T5,Y5,Z5
5120 NEXT D1
5130 RETURN
```

DAT
FILM